WAR WOUNDS
AND
AIR RAID CASUALTIES

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FOREWORD

By SIR WILLIAM MACARTHUR K.C.B. D.S.O. M.D.

In announcing the appearance of the first article on the treatment of war wounds and air raid casualties in the *British Medical Journal* of April 15, 1939, the Editor said: "At the moment of going to press it looks as though the decision to print these articles may be justified by events. The forecast unfortunately has proved to be true, and the publication of the articles in book form finds us at war with Germany. Throughout the anxious months of the past year the medical profession, energetically guided by the British Medical Association, has been busy in preparing itself for action. The outbreak of war found us ready to take up our posts. The practice of medicine and of surgery must now be adapted to the altered circumstance, and many medical men will find themselves obliged to learn new techniques and new modifications of old ones. No one can do better than to make a start by reading the articles in this volume. I am sure it will prove of great practical assistance to those called on to deal with battle and air raid casualties in the present war."

These articles cover a wide range of war time casualties, whether falling within the surgical, psychological, or chemical domains, and information dealing with the problems of emergency medical organization has also been included. The papers have each been written by a recognized authority on the particular subject, and first-hand experience of recent campaigns, particularly that in Spain, has been fully drawn on to bring our knowledge up to date.

W. P. MacArthur, *Lieutenant-General*
Director General Army Medical Services

PREFACE

BY THE EDITOR OF THE *BRITISH MEDICAL JOURNAL*

THE signed articles now reprinted in book form have appeared week by week in recent months, interrupting the series on *Treatment in General Practice* which began at the end of 1934 and of which three groups were published later as Volumes I II and III under that title Most of the present series were originally given as lectures at the British Postgraduate Medical School others, supplementing them were contributed at our invitation. The purpose of these lectures and articles was plain to every reader and one duty only remains to thank the authors for their co-operation in a good cause and to express our gratitude to the distinguished head of the Army Medical Services for his kindness in writing a foreword to the collected series.

October 1939

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WAR WOUNDS AND AIR RAID CASUALTIES

THE TREATMENT OF WOUNDS IN WAR

By COLONEL J M. WEDDELL, F R.C.S

Experience gained in previous campaigns is by no means always reliable We have to be prepared for new types of destructive missiles and different conditions of fighting with the result that the technique of wound treatment may require considerable modification. For example the mobile warfare in South Africa over sun-dried relatively sterile soil was very different from the stationary trench warfare in France and Flanders. In South Africa it was found that with the application of the first field dressing and sterilization of the surrounding skin the majority of the wounds healed by first intention In France the fighting was mainly stationary and over cultivated and highly manured soil. The result was that the men in the trenches were soaked and plastered with grossly infected mud containing organisms of every variety including the anaerobes of tetanus and gas gangrene. In South Africa the majority of wounds were inflicted by the high velocity small bore bullet of the Mauser type and relatively few by shell fire. In the great war wounds from high explosive shells and shrapnel increased to an enormous extent and wounds from missiles of relatively low velocity such as trench mortars, bombs, and hand grenades, were added, with exceedingly severe results. The advances made in recent years in mechanization and the power of the air arm will present new problems in the way of medical organization and requirements

In the field wounds are inflicted by bayonet, sword and lance by high velocity small bore rifle and machine-gun

bullets ; by shrapnel and high-explosive shells , and by bombs, hand grenades, and trench mortars

EFFECTS OF MISSILES

Bayonet, sword, and lance wounds are relatively infrequent in modern warfare Many soldiers are killed outright on the field, and few survive to come into the hands of the surgeons The wounds may be of any nature, corresponding to the type of weapon employed

Rifle and machine-gun bullets depend for their effect on the velocity of impact and also on instability The modern pointed bullet is more unstable than the blunt-nosed Mauser type, and inflicts more severe damage on internal organs That is to say, there are relatively fewer clean perforations of bone and viscera, and more damage is done to the internal organs in the way of laceration and disruption The small-bore bullets have a fixed weight and shape, and a high initial velocity which is lost slowly They have great power of penetration and relatively infrequently lodge in the body They do not tend to carry clothing into the wound Explosive exit wounds at short ranges are almost invariable Multiple wounds are uncommon, except when inflicted by machine-gun bullets or when the same bullet traverses several parts of the body The explosive does not affect the wound

Shell fragments, shrapnel, etc , have no fixed weight or shape They have a lower initial velocity, which is lost more rapidly They are haphazard in action, often cause multiple injuries, and depend for effect less upon velocity than on the size and shape of the fragments They have a lower power of penetration and often lodge in the body They frequently carry clothing and gross dirt into the tissues Explosive exit wounds are rare The effect of the explosive is as destructive as the fragmentation (that is, blast)

INFECTIVITY OF MISSILES

All missiles must be considered as infected The high-velocity rifle and machine-gun bullets, while they do pass through dirty clothing and unwashed skin, do not tend to carry clothing into

the wound, and the infection is as a rule more superficial and more amenable to surgical treatment. Shrapnel, shell fragments, and fragments of missiles of relatively low velocity (bombs hand grenades etc.) very often carry clothing and gross dirt into the wounds and all such wounds must be regarded as heavily infected.

Infection of the wound track is a most important factor Experience has shown that organisms are implanted into the wound track, but do not tend to invade the surrounding tissues for about twelve hours. It is obvious that the application of antiseptics cannot sterilize the tracks of deeply penetrating or perforating wounds. The only effective method of rendering such wounds sterile is by early and efficient surgery and if this can be carried out as soon as possible and certainly before the lapse of twelve hours, there is a good chance of eradicating the infection, and in a considerable number of cases the wounds can be closed by primary suture. It must be stressed that these primary sutures take considerable time and must be done by an experienced surgeon under the best aseptic conditions in some cases excision cannot be carried out completely for anatomical reasons To close an inadequately excised wound is to subject the patient to a very grave risk to limb or even life. Primary suture is the ideal treatment.

In cases received later than twelve hours or when satisfactory excision of the wound track cannot be carried out the method of delayed primary suture is most useful. This consists in excision of the damaged skin edges and track as completely as possible removal of any foreign bodies and efficient haemostasis. The wound is left open and packed with gauze soaked in flavine or some mild antiseptic If progress is favourable such wounds can often be closed by secondary suture three or four days later Incidentally cases treated by this method stand transport quite well and can be evacuated as soon as they have recovered from operation To give these operations the best chance of success it is essential to get the patients to the operating centre as rapidly and in as good condition as possible for operation. Therefore the principles of early treatment are the control of haemorrhage the prevention of shock and rapid evacuation

Plaster-of-Paris.—Many good results have been reported from Spain from the immobilization of infected fractures and wounds of the limbs in plaster on the lines of the Winnett-Orr treatment for osteomyelitis. Immobilization is of very great value in the treatment of war wounds. I am of the opinion that this form of treatment should be reserved for the base hospitals and not be used in the early stages, when there is any possibility of an anaerobic infection.

AT THE DRESSING STATION

In the field rapid evacuation is contraindicated in certain cases. These are cases in which shock is likely to develop or be aggravated during transport. Operation is therefore advised at dressing stations:

1. To control haemorrhage.
2. For the removal of crushed and mangled extremities. This can be carried out satisfactorily with local anaesthesia and often without an anaesthetic at all, as the limbs are frequently in a condition of "local" shock and sensation is absent.
3. Suture of gaping or valvular pneumothorax. This is most useful in cases where there are large open wounds into the pleural cavity. The tissues of the thoracic wall down to and including the muscles can be drawn together with temporary sutures to close the opening. This gives great relief to the respiratory distress of these patients, and can quite well be done with local anaesthesia or even no anaesthetic at all. If it is not possible to suture such a wound, packing the cavity with a large pad of moist gauze and approximating the wound edges with strapping will also afford considerable relief.

The treatment of gunshot wounds involves first aid and operation. First aid is given to tide over the immediate necessities of the patients, to relieve their pain, and to put them in as good a condition as possible for operation. Operative treatment will be necessary for all the more severe types of wounds if time and conditions permit. The principles of first-aid treatment are the control of haemorrhage, the application of a protective

dressing to the wound and the immobilization and extension of fractures and the prevention and treatment of wound shock

CONTROL OF HAEMORRHAGE

Tourniquets are not nearly so frequently necessary as might be imagined and a tourniquet can be a very dangerous weapon Every patient on whom a tourniquet has been applied must be clearly labelled with the time of application The pressure needed is only equal to that of the blood pressure The dangers are (1) Local infection which almost invariably follows the prolonged use of a tourniquet. Massive gangrene of limbs has occurred on many occasions (2) Tissue damage and shock (3) They are very painful Tourniquets are more dangerous on the upper than on the lower extremity

FRACTURES

The immobilization and the extension of fractures at the earliest possible moment are of the utmost importance Immobilization during transport adds very greatly to the comfort of the patient and is of much assistance in the prevention of shock. Considerable swelling may appear in a wounded limb within a few hours from either haemorrhage or inflammation Such swelling occurring under a firmly applied splint may cause pressure effects varying from a local pressure sore to complete gangrene of an extremity It should therefore be the rule (at a dressing station) to take down and examine any splinted limb in which there is excessive pain or in which the circulation of the extremities appears to be impeded

PREVENTION AND TREATMENT OF SHOCK

Without going into the pathology of wound shock there are several points in the treatment of the wounded which undoubtedly do prevent shock or assist in its treatment. These are

Warmth—It is essential to keep the patients warm but not overheated, as this will cause excessive loss of fluid by sweating A patient on a stretcher must be protected with a waterproof

sheet, and blankets underneath as well as on the top Artificial heat can be employed in the way of hot bottles, electric cradles, etc Ambulances must be warmed

Restoration of Fluid —In gunshot wounds the patients are often suffering from a shock-haemorrhage complex Therefore haemostasis and the restoration of fluid to the tissues are of vital importance For those who can take fluid by the mouth, hot sweet tea is an excellent means of restoring fluid and warming the patient Other means are intravenous infusions and the transfusion of blood

Relief of Pain —The injection of morphine ($\frac{1}{4}$ to $\frac{1}{2}$ grain) is an excellent sedative, whenever morphine has been given it is essential that a record should be made of the dose and time of injection, and this must accompany the patient

SOME USEFUL POINTS

As already mentioned, the immobilization and extension of fractures are of the utmost importance Patients should be handled and moved gently and placed in as comfortable a position as possible—for example, flexion of knees in abdominal wounds Unnecessary changing of dressings should be avoided

The following are a few points in the early treatment of some special cases

Wounds of the Spine —Fractures and wounds of the spine should be transported in the prone position on a stretcher, with the exception of wounds and injuries to the cervical vertebrae In these the patient should lie on his back with a stiff pillow or support under the neck to avoid flexion The above will apply especially to cases with spinal injuries from falling masonry or from being buried in trenches In wounds of the spinal cord with paraplegia no attempt should be made to pass a catheter; the bladder should be allowed to distend and overflow, or expression may be tried The most satisfactory method of preventing infection of the urinary tract in these cases is by a suprapubic cystotomy, which should be done at the operating centre

Wounds of the Jaws —Danger of suffocation is most commonly due to loss of control of the tongue In this condition posture

is of vital importance and the wounded man should be placed on the stretcher in the prone position with the head hanging downwards over the end of the stretcher It is essential to keep the tongue forward in these cases and many lives might in this way be saved by stretcher bearers and others Correct posture will also tend to lessen haemorrhage by keeping the tongue in a forward position, but it may be necessary to plug wounds external to the mouth and to apply digital pressure

By the courtesy of the President I had the opportunity of discussing the following points at a Committee composed of four members of the Council of the Royal College of Surgeons.

The Thomas Splint—In the Army we rely on the large-ringed Thomas splint for the evacuation of the majority of lower limb fractures from the front line to the casualty clearing station. The splint is applied over the boot and clothing and the ring is packed anteriorly and laterally with tow or wool to retain it against the tuber ischii. The fracture is supported with Gooch splinting or Cramer's wire extension is obtained by means of a skewer through the waist of the boot or a clove-hitch round the ankle and tied to the distal extremity of the splint The splint is suspended to a bar fitting over the stretcher Many modifications of the Thomas splint have been suggested, such as collapsible splints, half ringed splints, etc It was agreed that for the evacuation of casualties in the early stages the original Thomas model was the most satisfactory As one member of the Committee put it, "a Thomas splint altered is a Thomas splint spoiled." Cramer's wire splinting would form a useful support for arm fractures and fractures of the foot and ankle.

Skeletal Traction for Fractures—It was agreed that internal traction by pins and wires was unsafe unless one was certain of first-class aseptic conditions—that is to say skeletal traction is completely ruled out in dressing stations and probably even in a casualty clearing station from which patients are evacuated by ambulance train it is safer to rely on skin traction.

Plaster-of Paris—In the form of supporting slabs this would be of great use in casualty clearing stations. The encircling of

compound fractures with circular plaster bandages is dangerous in the early stages

Blood Transfusion—That extensive use would be made of blood transfusions, and that stored blood in refrigerators could be used in the dressing stations and forward area That "drip transfusion" would be of great value in the casualty clearing stations

Advanced operating units are not advised, as it is considered better to get the patients to the casualty clearing station, where they could be operated on and remain for some days and be nursed under better conditions Patients do not stand evacuation well after serious operations

Anaesthetics—It was agreed that gas-and-oxygen is the most suitable anaesthetic for the serious cases, and should be reserved for these This involves the use of heavy and cumbersome cylinders, the supply of which might be difficult For many cases ether may be used, and should be regarded as the standard anaesthetic The employment of the barbiturates for patients already in a condition of shock is definitely dangerous This also applies to spinal anaesthesia

IMMUNIZATION AGAINST TETANUS

With regard to tetanus, steps are now being taken to protect the Regular Army by means of active immunization with tetanus toxoid. This is administered in two doses of 1 c cm , given at six-week intervals, and affords a degree of immunity which, so far as can be deduced from animal experiments, is more than sufficient to prevent infection Although definite information is not yet available it is believed that the immunity produced in this way is of long duration As our knowledge of the subject is as yet somewhat incomplete, this measure is being regarded as an additional line of defence, and it is proposed to give immunized soldiers who have received potentially infected wounds a single dose of 3 000 units of tetanus antitoxin The necessity for this procedure may be in some cases rendered imperative by absence of information regarding previous active immunization

MEDICAL ORGANIZATION IN THE FIELD

By COLONEL J M. WEDDELL, F R.C.S

The wounded are collected from the firing line by the regimental stretcher bearers (non medical personnel trained in first-aid) the first field or shell dressing and possibly temporary splints, are applied, and the wounded are carried or directed to the regimental aid post, where the medical officer of the unit is located

Regimental Aid Post —Here first aid is given urgent haemorrhage is controlled by direct pressure or forci pressure, and in cases of absolute necessity by a tourniquet. Morphine is administered if necessary (the dose and time being noted on the field card) The patient is kept warm with waterproof sheet and blankets and is evacuated as soon as conditions allow to the advanced dressing station by the stretcher bearers of the field ambulance

The Field Ambulance —This is the first medical unit to receive the wounded. The field ambulances move in the rear of the fighting troops and, when contact with the enemy is made one company establishes a post known as an advanced dressing station within reasonable distance of the regimental aid posts.

Advanced Dressing Station —The surgical possibilities here are very limited and consist in the control of haemorrhage the splinting and extension of fractures, if not already carried out, and measures for the prevention of shock. Dressings and splints should be examined and if satisfactory left alone morphine is administered if necessary and the dose and time entered on the field card The advanced dressing stations are situated well forward so as to be in touch with the regimental aid posts to save the stretcher bearers carrying for long distances and, of necessity are often in the zone of fire In stationary warfare they are frequently in dug-outs.

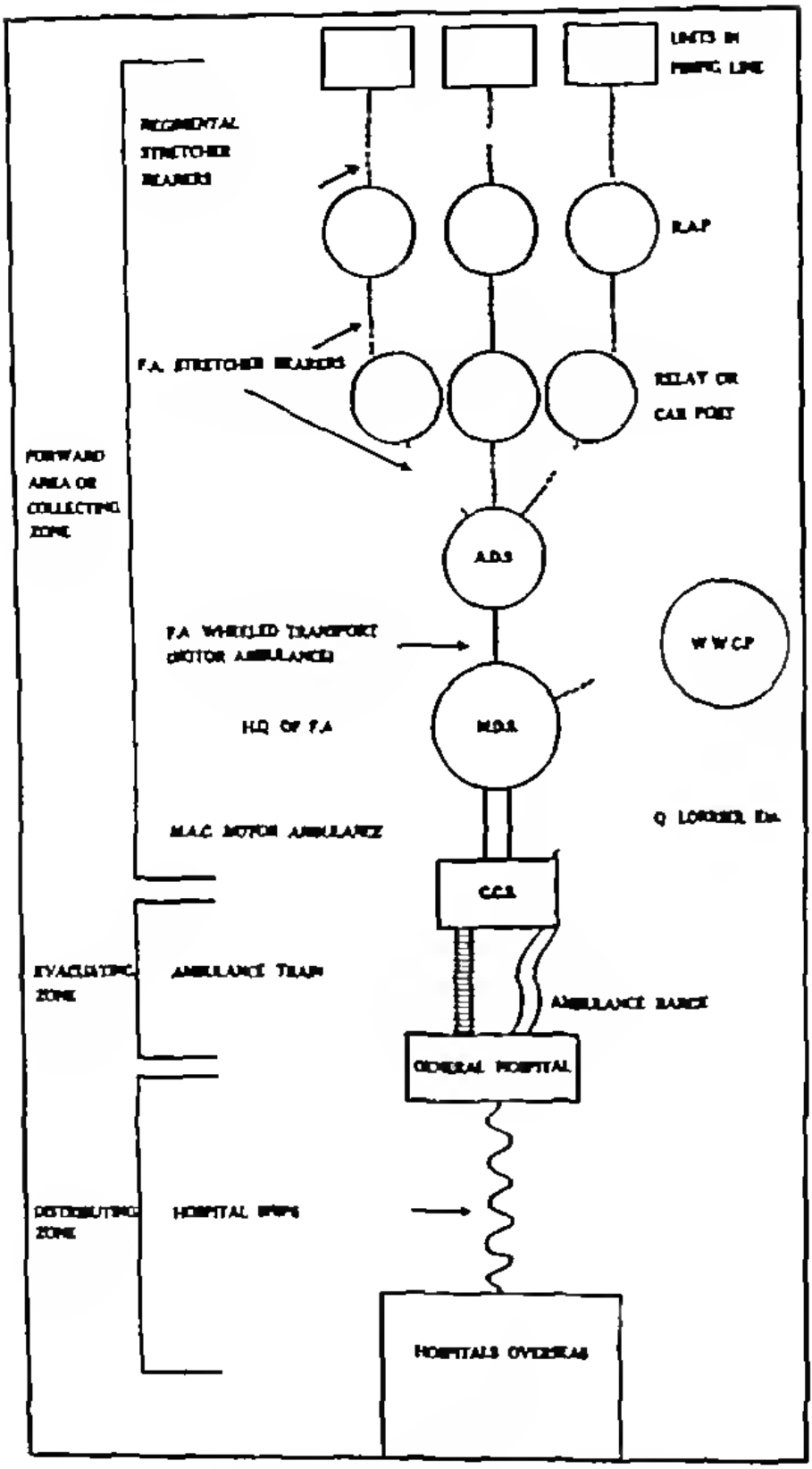
A Walking Wounded Collecting Post—This may often be arranged with advantage when heavy fighting is expected This should be close to the advanced dressing station and near a road leading to the casualty clearing station for evacuation

Main Dressing Station—This is the next medical post, which is established by the headquarters of the field ambulance In France the main dressing stations were as a rule two to six miles behind the fighting line Here emergency operations can be carried out, such as ligation of bleeding vessels, amputation of shattered or crushed extremities, and the closure of open sucking chest wounds A dental surgeon is also here to assist in the emergency treatment of maxillo-facial injuries More active measures for the prevention and treatment of shock are possible, and infusions or transfusions of blood may be given Here the routine injections of anti-tetanic serum are given and noted on the field card

In these days of increased mechanization it may be possible to cut out one or even both of these dressing stations Anything that will lessen the time of evacuation and avoid unnecessary unloading and reloading of patients in ambulances and get them more quickly to the operating centre must be of great benefit

THE CASUALTY CLEARING STATION

The casualty clearing station is the principal surgical unit and operating centre in the forward area These units form the connecting links between the forward area and the hospitals on the lines of communication They are equipped with operating theatre, *x*-ray department, laboratory, etc, so that all major surgical operations may be carried out In France the C C S s were usually ten to fifteen miles behind the firing line, beyond the range of severe shell-fire They should be on or near a railway line, so that evacuation by ambulance train can be carried out They are designed to take 200 patients normally, but can expand to receive very many more In the great war eight to ten operating teams were often working simultaneously and continuously for several days



DIAGRAMMATIC SCHEME FOR EVACUATION OF CASUALTIES.

PREVENTION AND TREATMENT OF SHOCK

By COLONEL E M COWELL, D.S.O., T.D., F.R.C.S.

The term "shock" should not be used unqualified. In civilian surgery it should be preceded by the word "surgical" or "traumatic", and in military or air-raid surgery the term "wound-shock" (1917) is accurate and descriptive. This terminology avoids confusing the condition with "shell-shock" or shock resulting from a transient psychical disturbance.

Wound-shock is not a nervous phenomenon; indeed, the nervous system occupies only a small part of the picture. The conception of wound-shock as being a condition of *failure of the circulation* is all-important. It may be defined as a condition of lowered vitality of the body resulting from injury or accident, which leads to failure of the circulation, with lowering of the blood pressure, reduction of the body temperature, diminution of the blood volume and concentration of the blood, intra-cellular anoxaemia, and, in untreated cases, subsequent death. An excellent discussion of the theories of traumatic shock may be found in Cannon's book (1923A). None of the theories, however, were very helpful in the matter of treatment, and vast numbers of wounded died from shock in the first years of the great war.

FINDINGS OF SHOCK COMMITTEE IN 1917

Early in 1917 a Shock Committee was established in London, and the first memorandum on the subject was published. Experimental work was undertaken by Bayliss and others in this country, and clinical observations were made by Fraser, Hooper, and Cowell in France. W. B. Cannon arrived from Harvard and took an important part in the investigations, working with Bayliss in London and Fraser in Béthune. It was felt that much might be learned from studying the actual conditions under

which men were wounded, and by making clinical observations immediately the man was hit and in the next few hours while he was being transported to the casualty clearing station No 33 Casualty Clearing Station was the receiving hospital where Fraser and Cannon worked in the operating theatre and laboratory respectively and Cowell made observations in the trenches on Hill 70 following the casualties to the regimental aid posts and advanced dressing station in Loos From this study it became clear that wound-shock could be classified into two types primary which was rare and occurred only in wounds which were almost immediately fatal and secondary—the common type—which was of slow onset and occurred in the presence of one or more of four definite factors.

COLD

Observations were made in September 1917 on Hill 70 in front of Loos It was a cold moonlight night, with a chilly wind blowing A soldier's blood pressure had just been taken when a hand grenade was thrown over from a German post and wounded him in the foot and neck relatively trivial wounds. The blood pressure which was 110 mm a short while previously was at the same level immediately after the wound. A bearer party carried him shoulder high through shallow trenches over the hill to the regimental aid post. He had no blankets and became steadily colder and colder When he arrived at the regimental aid post an hour later he was pulseless. Two hours afterwards at the advanced dressing station, which he reached on a wheeled stretcher he was still pulseless, and a serious view was taken of his condition. He was hurried off to Béthune in an ambulance car and was found at the casualty clearing station to have a pressure of 80 mm. with no palpable pulse. After being warmed up in bed and being given hot drinks the shock soon passed off in the absence of any heroic measures of treatment

McDowall (1923) quotes work by Dale and others which shows that histamine shock can be induced in certain carnivora only when the suprarenals are destroyed. He also states that Cramer and Crowden have shown that these glands are exhausted by

cold Holt and Macdonald (1934) also say that, in experimental shock, "if no attempt was made to sustain the normal body temperature, shock was maintained much more readily"

PAIN

In war wounds pain is always present, but it is difficult to estimate this factor by itself An opportunity, however, arose of observing the blood pressure in a case of renal colic The pressure dropped from 130 to 60 and only rose after fifteen minutes, when the patient could no longer stand the pain and morphine was given A few minutes later the pressure rose to its original level Crile has advised blocking the afferent nervous impulses in order to prevent shock This is not necessary provided that pain is checked by the administration of morphine or a suitable general anaesthetic I performed a fore-quarter amputation in a feeble lady of 70 for sarcoma of the upper end of the humerus Gas-and-oxygen was administered and the pressure taken every five minutes The brachial plexus was left intact until every other structure had been divided, and no fall in blood pressure occurred

HAEMORRHAGE

There is a bleeding to a variable extent in all war wounds In air raids, where the wounds are generally severe and multiple, and when immediate first aid is difficult owing to the large numbers of casualties that may occur at one spot, bleeding is an important factor in the initiation of shock The quantity of circulating fluid becomes diminished, leading to deficient intracellular oxygenation This weakens the heart's action, so establishing a vicious cycle Bodily fluid is also lessened by the profuse sweating which accompanies shock In the case of the fighting soldier an anhydraemia may exist before he is wounded and be an important pre-wound factor in the production of shock

TOXAEMIA

Early one morning I met a stretcher party carrying a strong burly lance-corporal who had just had his left leg blown off by

a trench mortar Efficient first aid had been applied, and I saw him attended to by the regimental M.O., who readjusted the dressing on a stretcher heated by a primus stove placed underneath The man was quite fit the blood pressure was 115 mm., and the pulse rate 96 I accompanied him on his two-hour carry to the A.D.S in Loos and found on arrival there that the blood pressure was maintained but the pulse rate had crept up to 120 He was not in pain, was quite warm, and there was no bleeding At the casualty clearing station two hours later the pressure had fallen and secondary shock was present. Early gas gangrene was found, the stump was reamputated and he recovered. This case I regarded at the time as an example of bacterial toxaemia Another case was seen where the arm was amputated for a shattered humerus soon after the receipt of the injury Four hours later I saw the man on his way down the line and found him surprisingly fit, with a blood pressure of 140 and a pulse rate of 90 Here all traumatized tissue had been removed and the toxic factor eliminated.

Much experimental work has been done on the absorption of toxins produced by trauma of the tissues Bayliss and Cannon showed in 1918 that shock followed severe traumatization of the animal's leg with nerves cut but blood vessels intact, and concluded that this shock resulted from toxic absorption. Holt and Macdonald in 1934 repeated these experiments with negative results M. I. Smith (1927-8) claims that direct methods have failed to demonstrate a depressor substance in the blood of a shocked animal McDowall (1923) admits that toxic or chemical shock exists, and refers to the well known fact that shock may occur acutely when a tourniquet is removed from a severely damaged limb and the products of damaged tissue are allowed to enter the circulation This author also agrees that this shock is enhanced by cold and by chemical poisons such as ether and chloroform. From the experimental point of view toxaemia is not yet accepted as a causal factor of shock. Clinically however there appears to be no doubt in the matter

PATHOLOGICAL FINDINGS IN WOUND SHOCK

Reduced Blood Volume—Some of the most important observations in wound shock were made by Keith (1919) This observer measured the blood volume in a series of cases and found it reduced to 52–85 per cent of the normal, at the same time there was a plasma reduction ranging from 62–90 per cent He described three groups

1 Compensated cases, with slight symptoms, pulse 90–110 and blood pressure above 110 mm. The blood volume never falls below 80 per cent of the normal, and the plasma is not reduced in proportion

2 Partially Compensated Cases—There is a history of a small haemorrhage the patient is restless, cold, and thirsty, and he vomits, pulse rate 120–140, blood pressure 70–80, and blood volume 65–75 per cent, with slow dilution of the plasma, 70–80 per cent reduction only

3 Uncompensated Cases—Condition very serious, with extreme restlessness, thirst, and vomiting The extremities are cold and the pulse impalpable The blood pressure may be as low as 60 mm, and the heart rate 120–160 The blood volume is below 65 per cent and the plasma volume correspondingly reduced

Cannon (1923B) concludes his chapter on blood volume "The dictum uttered by the older generation of surgeons, that 'shock is haemorrhage and haemorrhage is shock', is true"

Where is the Lost Blood?—A certain amount of loss may be accounted for by bleeding However, shock may occur without haemorrhage, and in these cases there is evidence to show that the lost blood accumulates in the capillaries Simultaneous red corpuscle counts of blood from the veins and capillaries show a greatly increased count in the latter

Transudation of Plasma—Blalock (1930) found that trauma in the thigh of an animal results in extravasation of serum into the loose tissues of the groin and flank On weighing both lower limbs after careful amputation he found the difference in weights amounted to at least 4 per cent of the body weight, or about half

of the total calculated blood (blood being one-thirteenth of the body weight)

Increased Viscosity of Blood—Cannon points out that the viscosity of the blood is complex consisting of (*a*) the internal friction of the plasma, (*b*) the friction of the corpuscles with the plasma and with each other and (*c*) the frictional contacts of the corpuscles with the vessel walls especially in the capillaries. Trevan (1918) states that internal friction rapidly rises as soon as the corpuscles reach a concentration of 60 per cent , they have a tendency to stagnate especially when the arterial pressure is decreased. This stagnation in addition to haemorrhage and loss of plasma would further augment the amount of blood which is out of currency and consequently conduce to failure of the circulation.

Effects of Reduced Blood Volume and Blood Pressure—Vaso-constriction occurs in certain organs reserving the diminished blood volume for essential organs (Cannon) As the blood volume continues to diminish the pressure falls and all parts of the body begin to suffer from disturbances of the circulation From his study of the subject of cerebral anoxaemia Cannon concludes

It is probable that, as the result of reduced blood volume and lowered blood pressure the transportation of oxygen is greatly decreased in amount Many observations on the reduction of the alkali reserve, basal metabolism and changes in blood and urine are described in Cannon's book, but will not be discussed here. With regard to the importance of the time factor in the development of shock the gradually damaging effect of persistent low pressure is of the greatest consequence in both understanding and treating shock When the vasomotor centre has lost its capacity to maintain vascular tone there is no known remedial agent that will bring back the blood flow to its normal condition. Even blood transfusion leads to no permanent gain. At this stage the damage due to insufficient oxygen is too great to permit of resuscitation From the practical point of view a pressure of 80 mm. or lower if not raised within four hours, will have a fatal result

PREVENTION OF WOUND SHOCK

The Clinical Picture —The main symptoms are well known In looking round a resuscitation ward filled with wounded awaiting anti-shock treatment, the most striking features are the cyanosis of lips and finger-tips, the coldness of the extremities, and the restlessness Sweating and vomiting are seen in the earlier stages

When the causal factors of this condition became clear, and with the recognition that secondary wound shock was the commoner variety, the conception of the idea of prevention occurred This gave great encouragement to the war-weary regimental medical officer, and a new campaign to combat shock was begun with enthusiasm All concerned in the early treatment of wounded, both medical officers and other ranks, were taught the four causal factors Every endeavour was made to get the casualty to hospital before shock could develop *Cold* was prevented by supplying hot-water bottles, hot bricks, and hot drinks Stretcher parties were encouraged to carry a blanket-packet in forward areas This consists of a blanket folded in a waterproof sheet to the same size as a stretcher pillow, and is carried in the same way in a closed stretcher (*R A M.C Training Manual*, 1935) In the regimental aid post the man was given three blankets, folded in such a way that there were four thicknesses behind him as well as in front. Also before being sent on he was thoroughly warmed by a stove under his stretcher and by a drink of hot sweet tea The ambulance cars were warmed as well, and cases were actually observed in which wound shock disappeared on the journey, entirely owing to the warming measures adopted

Pain should be prevented by efficient first aid, careful handling, and adequate splinting of injured limbs If these measures are carried out properly morphine will not be necessary *Bleeding* is treated by efficient first aid, the judicious use of the tourniquet, and possibly by simple surgical intervention at a forward dressing station *Toxaemia* may be minimized by efficient immobilization of a damaged limb, but is chiefly combated by rapid evacuation

The front-line application of the Thomas splint for wounds

of the lower limb affords an illustration of the use of the above-mentioned methods of preventing shock.

TREATMENT OF ESTABLISHED WOUND SHOCK

Treatment depends on a recognition of the four factors and a knowledge of the pathology of the condition When large numbers of wounded are being received, and if the military situation permits, definite resuscitation wards are organized for the treatment of wound shock both at the main dressing station and at the casualty clearing station Careful judgment and close watching will determine the right moment for surgical intervention, when the *cause* of the condition will be dealt with and removed. To operate in shock is dangerous but in certain cases and with adequate precautions surgical intervention must be risked to save the patient's life For example, after a massive blood transfusion and with gas-and-oxygen anaesthesia it is justifiable to perform an amputation, open an abdomen, or close an open pneumothorax.

In the resuscitation ward the patients are warmed by hot-water bottles electric cradles hot-air cradles, or stoves under stretchers on trestles. Morphine is given for pain in repeated small doses if necessary The deficiency of circulating fluid (anhydraemia) is made up by giving hot drinks saline by rectum, and, in severe cases, intravenous injections of hypertonic glucose saline with maulin gum or blood. In Spain where blood transfusion was highly organized, it was found that 10 per cent. of wounded required blood, and in the resuscitation wards, where blood was given to all moribund cases and to those considered hopeless some 20 per cent. recovered sufficiently to stand operations

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BLOOD TRANSFUSION

By JANET M VAUGHAN, D M., F R C P.

I PROPOSE to discuss the problem of blood transfusion particularly from the point of view of a war-time emergency service, though much of what I have to say is also applicable to a transfusion service in times of peace

SOURCES OF BLOOD FOR STORAGE

Blood for purposes of transfusion may be freshly removed from a living donor and immediately given to the patient, or blood that has been stored may be used It is obvious that under war conditions fresh blood cannot be given as a routine. The disorganization of means of communication caused by aerial bombardment makes it impossible to call upon donors at those times when blood is most needed Medical and surgical personnel will be required to attend to patients during severe air raids or at periods of active fighting They must administer blood and not spend time withdrawing blood Donors obviously cannot be sent up to the front-line dressing stations It will be absolutely essential, therefore, to have adequate supplies of stored blood

Recognized sources of blood for storage are the placenta, the cadaver, and adult donors Even in ideal circumstances the yield of blood from the placenta is small, on an average 80 c cm Though certain workers advocate its use, at least in times of peace, opinion on the whole suggests that the labour involved in its collection is not repaid by the small amounts of blood which result (Goodall *et al*, 1938, Howkins and Brewer, 1939, Page *et al*, 1939, Halbrecht, 1939) Cadaver blood has not been used in this country In Russia it is claimed to be satisfactory (Yudin, 1937) On theoretical grounds, in time of war it should prove an excellent source, since in persons dying a

sudden death spontaneous fibrinolysis occurs, and it is not therefore necessary to use an anticoagulant In practice, however the collection of blood from war cadavers has, according to Saxton (1939) and Duran (1939) proved unsatisfactory

Stored blood from adult donors has, however been an almost universal success. Recent experience in this country confirms the work of Russian (Filatov, 1937, Bagdassarov, 1937) and Spanish workers (Duran 1939) on this point (Elliott Macfarlane and Vaughan, 1939, Boland, Craig and Jacobs, 1939) Biddle (1939) has for the last year used nothing but stored blood at the Ipswich Hospital He claims that in giving 150 transfusions he has had fewer reactions than during the period when he used fresh blood He had slight reactions in about 5 per cent. of his cases Experience in the department of pathology of the British Postgraduate Medical School has been similar In receiving fifty consecutive transfusions with stored blood four patients had a slight rise of temperature and four had mild rigors. Saxton (1939) has reported a higher reaction rate in Spain, but it appears probable that complicating factors may have been present.

Such figures as are available suggest that the rise in red cells and haemoglobin following the use of stored blood is as satisfactory as that achieved by fresh blood while improvement in the clinical condition of the patient is equally good provided that certain criteria of satisfactory preservation to be discussed later, are adhered to (Elliott Macfarlane, and Vaughan 1939)

BLOOD TRANSFUSION INSTITUTES

Experience both in Russia and in Spain has shown that the best results are obtained if blood is withdrawn stored and distributed from special centres equipped for the purpose It is obvious that the existence of such centres does not prohibit small and isolated units from arranging for their own supplies in times of emergency It is however, easier to ensure adequate sterility of apparatus and methods of collection when trained personnel work in suitably equipped institutes.

DONORS

It proved possible in Spain, in spite of war-time conditions, to organize a service of donors who came up to give blood at regular intervals Blood was withdrawn, apparently without ill effects, as often as once every three weeks in many cases On theoretical grounds it would be wise to have a longer interval—if possible at least three months, as is advised at present by the Red Cross Voluntary organization Such a period will, however, clearly prove impossible in time of war About 500 to 600 c cm. of blood is a reasonable amount to take from each donor It has been suggested that it is wiser to take blood from a donor who has had no food for several hours. We kept a careful note of the time and character of the last meal in all donors of blood for storage, and could not detect any relation between reactions and the recently fed donor

In Barcelona, Duran (1939) stored blood from Group IV Moss (O international) donors only, since under war conditions adequate grouping at the front proved impossible In our limited experience here in peace time we found that it was wise to keep blood of all groups This policy resulted in no wastage If donors are to be bled as often as once a month they should be given large doses of iron, and if possible extra rations, under war-time conditions, at the time of withdrawal

APPARATUS

Various types of apparatus have been used for the withdrawal, storage, and administration of blood No one method is at the moment completely satisfactory On theoretical grounds the ideal technique for war time should fulfil the following conditions

1 The whole apparatus must be autoclaved in one piece ready for use without further manipulation if sterility is to be secured

2 Blood must be collected without exposure to air for the same reason

3 All glass-ware must be strong

4 The container should be completely filled to reduce movement of blood to a minimum Even slight shaking of blood after storage for longer than twenty four hours is found to increase haemolysis so that any technique that reduces agitation to a minimum is to be advocated.

5 No glass tubing should be left in contact with the blood after collection as it is found to favour clot formation.

6 The technique of both collection and administration should be as simple as possible

The method described by Duran (1939) fulfils the first four of the above conditions. The special storage vessels required, however even if somewhat simplified are not easy to obtain on a large scale Further the method of collection and closing of the storage vessels appears too complicated for emergency conditions where extremely large quantities of blood may be needed. The technique described by Elliott and others (1939) fulfils the first five conditions. The vessel is however completely filled and in order to give blood by a pressure method a two-way tap and syringe is required. This can well be manipulated by a single individual, but it might be thought that it makes the apparatus too complicated for emergency use where skilled personnel will not necessarily be available

Some modification of Boland, Craig and Jacobs's (1939) method, using a different type of filter will probably prove the most satisfactory technique available should emergency immediately arise Both collection and administration are easy and no complicated apparatus is required The vessel is not, however completely filled with blood, and if shaken in transit haemolysis is likely to occur The risk is lessened if blood is transported immediately after collection, since red-cell fragility is not greatly increased in the first twenty four hours of storage If pressure is needed it can be obtained by means of a Higginson syringe In giving blood to patients suffering from severe shock or haemorrhage whose veins are likely to be collapsed, some form of pressure is a great advantage. In many cases it saves the necessity of cutting down on the vein and inserting a cannula.

METHOD OF COLLECTION

In collecting blood for storage it is essential to adopt a strictly aseptic technique We found three instances of contamination with *Staphylococcus aureus* in our first twenty samples of blood withdrawn with reasonable precaution After that, more rigid rules were laid down regarding asepsis, and no further contamination occurred. The operator wore a mask and scrubbed up as he would in the theatre. The skin over the antecubital fossa of the donor was cleansed with soap and water and then with alcohol. The whole apparatus, including the needle and preservative required for collection, was autoclaved together, so that it was not handled in any way, and it was so arranged that the blood was never exposed to the air

Blood that flows freely into the preserving fluid keeps in more satisfactory condition than blood that flows slowly. It is therefore important to place the donor in a comfortable position with his arm near the edge of the arm rest, so that no kinking of rubber tubing can occur. If care was taken over the comfort and position of the donor it was found that 500 c cm of blood could be easily collected in from four to seven minutes Before cleaning the donor's skin we placed an ordinary blood-pressure cuff round the upper arm and maintained a steady pressure of 80 mm Hg Boland and others (1939) have described the collection of blood in a flask containing a partial vacuum Other workers have advocated the use of a Higginson syringe to maintain a negative pressure in the collecting vessel Before withdrawing the needle from the vein, and after disconnecting it from the collecting flask, a few drops of blood should be taken into a tube containing 1 per cent sodium citrate in normal saline for purposes of grouping, and into a second tube for a Wassermann test For convenience these two small tubes may be slipped under a rubber band attached to the collecting vessel before it is autoclaved.

PRESERVATIVES

Four preservatives have been used (i) sodium citrate in varying concentration , (ii) physiological citrate ; (iii) glucose

citrate and (iv) a mixed salt solution known as I.H.T (see table) We at first added 10 c.cm. of 3 8 per cent. sodium citrate to every 90 c.cm. of blood giving a concentration of 0-38 per cent. sodium citrate approximately similar to that used by

TABLE SHOWING PRESERVATIVES USED IN STORING BLOOD

Solution	Authority	Constituents	% Concentration	Volume of Solution	Volume of Blood	Final % Concentration
(1) citrate	Saxton	Sodium citrate	3 8	10	100	0-34
	Vaughan		3 8	10	90	0 38
	Duran		4-0	10	100	0-36
	Bagdassarov	"	6-0	10	100	0-54
(2) Physiological citrate	Page *et al*	Sodium citrate	1 25	10	10	0-625
		Sodium chloride	0-85			0-425
	Harrington and Miles	Sodium citrate	1-0	10	20	0-35
		Sodium chloride	0-85			0-28
(3) Glucose citrate	Domanig	Sodium citrate	1-0			0-5
		Glucose	2-0	10	10	1-0
		Sodium chlorate	0-2			0-1
	Duran	Sodium citrate	4-0	10	100	0-36
		Glucose	1-0			0-09
(4) I H.T	Moscow	Sodium chloride	0-7			0-35
		Sodium citrate	0-5			0-25
		Potassium chloride	0-02	10	10	0-01
		Magnesium sulphate	0-001			0-002

Saxton (1937) Bagdassarov has used a higher concentration—0-54 per cent. Repeated reference is made in the literature to the use of physiological citrate solution though I have been able to trace few figures for the exact composition of the solution.

Page, Seager, and Ward (1939) used 1 per cent of sodium citrate in 80 c cm of normal saline to which was added 80 c cm of blood Harrington and Miles (1939) have recently recommended the use of 1 05 per cent sodium citrate in 0 85 sodium chloride, one volume of this solution being added to two volumes of blood Glucose citrate is also mentioned, and the following formula is given by Domanig (1937) sodium citrate, 1 gramme, glucose, 2 grammes, sodium chlorate, 0 2 gramme, water, 100 c cm This is mixed with blood in equal quantities Duran is reported by Ellis (1937–8) to use a final strength of 0 36 per cent sodium citrate and 0 09 per cent glucose (see table) The majority of workers have employed a simple citrate solution We found that however carefully blood was mixed with the citrate solution clots always tended to form, which, though they were easily removed by filtration, made the administration of the blood rather more complicated than was necessary After twenty transfusions had been given with citrated blood we therefore used the anticoagulant first devised by the Institute of Haematology and Blood Transfusion at Moscow, commonly known as I H T (Bagdassarov, 1937) The formula is sodium chloride, 7 grammes, sodium citrate, 5 grammes, potassium chloride, 0 2 gramme, magnesium sulphate, 0 04 gramme, distilled water, up to 1,000 c cm It is mixed volume for volume with blood. Why this particular proportion of salts was chosen I have been unable to discover Results with its use proved satisfactory, and no further trouble with clot formation was experienced All observers agree that considerable dilution of blood for storage is an advantage, haemolysis occurs less readily, and, since stored blood anyhow tends to be sticky, dilution facilitates administration As much as 2,600 c cm of mixed blood and I H T has been given to a patient with no ill effects

GROUPING

This is not the place for a discussion of the technique of blood-group determinations It is necessary, however, to emphasize that accurate determination of blood groups is essential to the success of any transfusion service Severe reactions are almost

invariably due to the administration of incompatible blood. Such a mistake usually results from the use of weak test sera. All serum should have a minimum titre of 1 in 120 at least if it is to be kept for any length of time and preferably higher It is not always easy to find individuals with such a high titre One of the most important tasks of any large transfusion service should be to guarantee a supply of such serum.

No serum, however good, should be kept for more than six months. It should not be stored in small capillary tubes for longer than a few weeks. Serum is best kept in bulk frozen solid. A small supply should be put up in capillary tubes or 1 c.cm. ampoules, for immediate use It is probable that many of the severe reactions following the use of stored blood in Spain were due to wrong grouping dependent upon unsatisfactory supplies of test sera rather than to any inherent fault in stored blood. If possible cross matching between recipients serum and stored corpuscles should be carried out, but in times of emergency this may be a counsel of perfection.

STORAGE TEMPERATURE AND DURATION

We employed a temperature of 4° C for storage of blood. Satisfactory results have been reported with storage at a tem perature as low as 1° C and as high as 7° C (Bagdassarov, 1937 Boland *et al* 1939) Haemolysis occurs if blood is frozen.

All observers agree that blood begins to deteriorate after the fifteenth day of storage, though it can be given without ill effects after storage for thirty four days. We purposely kept some samples of blood so as to test the results of its administration, and found that even when it was thirty three days old the patient seemed none the worse for its administration. That after the fifteenth day less satisfactory results are obtained is probably dependent upon the fact that the red cells become increasingly fragile about this time and haemolysis increases rapidly The tendency to haemolysis becomes evident in citrated blood rather earlier than it does in blood preserved in I.H.T Elaborate studies of the effect of storage both upon red-cell characters and

the biochemical composition, have been made by Russian workers and are summarized by Filatov (1937) The sugar content decreases from the second day of storage, while the lactic acid content increases, together with the inorganic phosphorus Haemoglobin becomes more stable The albumin and globulin contents are constant for at least fourteen days The reaction becomes increasingly acid Complement is completely destroyed in fifteen days, and after seven days is reduced to 50 per cent The red cells remain unaltered for fifteen days, after that time they begin to show great variation in size and shape, and there is a rapid increase in cell fragility with increasing haemolysis The reticulum is lost after five days, presumably owing to ripening of the young red cells There is a gradual decrease in agglutinability. The sedimentation rate is gradually slowed The platelets are said to have completely disappeared by the fifteenth day, changes beginning on the first day of storage There is considerable divergence of opinion about the effect of storage upon white cells Filatov (1937) believes that degeneration begins between the third and fifth days Irger (quoted by Filatov, 1937) goes so far as to maintain that 57 per cent of the white cells are intact on the twenty-fifth day. In practice it is found that if the plasma immediately above the sedimented red cells is amber rather than red in colour no excessive haemolysis has occurred and the blood is suitable for use

STERILITY

The literature contains few precise statements concerning the sterility of blood withdrawn for storage In our own series of fifty samples blood was withdrawn by means of a capillary pipette from the main lot, for purposes of culture, the day after collection Four tubes containing heart broth were inoculated, two with 2 c cm. and two with 1 c cm, one from each set being incubated aerobically at 37° C and the other two anaerobically Cultures were plated out daily for fourteen days Three cases of contamination with *Staphylococcus aureus* occurred in the first twenty of the fifty samples collected The remaining thirty were sterile It is possible that this high rate of contami-

nation was in part due to technical factors which as already discussed were later eliminated The contamminant usually grew in abont half the tubes and did not develop until tho sixth day of culture Dr T C Stamp to whom we nre indehted for arranging for these tests, beheves that cultures should be kept under observation for at least one week before reporting a negative. Aratyunjan (quoted hy Filatov, 1937) reports 8 per cent. of contaminations in a series of sixty five samples, Shorina 3 9 per cent. of infections (quoted by Filatov 1937) Saxton reported a much higher rate of contamination in Spain. It is likely that under the stress of war time conditions sterilization of apparatus was far from satisfactory Any handling of the collecting apparatus, such as putting on a needle sterilized by boiling rather than using one attached to the rubber tubing before autoclaving, we found increased the contamination rate Unless contamination was gross wo were unable on naked-eye examination, to detect any difference between sterile and infected blood Biddle who tested a few only of his 160 lots of blood found them all sterile Boland *et al* (1939) out of forty samples of blood cultured, found two to be contaminated with *Staphylococcus albus*

Available evidence suggests that if the blood is withdrawn with a careful aseptic technique the risk of contamination is slight. In times of peace culture should be a routine Under emergency conditions it would be impossible to employ this additional safeguard Duran (1939) in his latest apparatus, stores the blood in contact with oxygen Anaerobes obviously cannot grow in these circumstances, while aerobes, if present consume the oxygen so that the blood which should be bright red, becomes dark in colour In this way in his opinion contamination is readily detected without the necessity for culture It has recently been suggested (Harrington and Miles 1939) that a definite amount of sulphanilamide should be added to stored blood. Until more careful studies have been made of the effect of drugs of this group upon serum this would appear unwise (Dameshek and Colmes 1938 Scott and Meerapfel, 1939)

preserved red cells. Duran (1939) pooled all blood taken from Group IV donors and sent out mixed lots for therapeutic use He found this method satisfactory and it obviated all need for cross matching

TRANSPORT

If the best results are to be obtained with stored blood it is essential that it should be kept at a low temperature until immediately before use Blood that has once been warmed even for a short time tends to deteriorate more rapidly than blood kept at a steady low temperature Special refrigerator vans were used successfully in Spain for the transport of stored blood up to front line hospitals. In designing such transport vans it is important to remember that stored blood should not be shaken more than is absolutely necessary Transport vehicles should therefore be fitted to carry containers in a steady upright position For the transport of small amounts of blood in times of peace the metal water bath and cork lined box used for keeping the blood warm during administration may equally well be used for keeping it cold

INDICATIONS FOR TRANSFUSION OF BLOOD

The relative merits of gum saline glucose saline and blood transfusion are always a subject of debate The chief value of transfusion is its immediate effect in increasing blood volume plasma proteins, haemoglobin concentration, blood platelets, and other factors concerned in blood coagulation In some instances it may act as a stimulus to blood regeneration (Vaughan 1936) In time of war transfusion is required primarily for patients who have had recent severe blood loss. The indications for transfusion in such cases must be largely clinical, since owing to the concentration of blood that occurs the red-cell count and haemoglobin estimation may be normal or even polycythaemic Restlessness pallor dyspnoea, a systolic blood pressure of 70 mm Hg or less, and a rising pulse rate are indications that blood transfusions are needed. Transfusions of fresh blood are also of definite value in patients with prolonged sepsis and anaemia due, for instance to a gunshot wound that fails to heal. Experi

ence in Spain suggests that possibly stored blood is not so effective in such cases, but carefully controlled observations on this point are still lacking

Experience has shown that stored blood is life-saving both in time of war (Saxton, 1937) and in time of peace (Elliott *et al*, 1939) It is clear, however, that much still remains to be learnt about the most satisfactory methods of preservation, about the changes that occur during storage, and about its value in conditions other than sudden haemorrhage

I must express my gratitude to Dr Duran Jorda for the information he has given me about his experience with stored blood in the Spanish war

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TETANUS AND GAS GANGRENE

By CLAUDE FRANKAU C.B.E. D.S.O. M.S. F.R.C.S.

It is obvious that any wound produced by a missile whatever its nature, will be potentially an infected wound. Simple perforating wounds of an exposed portion of the body, not involving the carrying in of infected clothing, may heal by first intention, but such an outcome is rare. Wounds in which the projectile is retained and in which fragments of clothing, etc. are embedded are of necessity infected, the degree of infection depending on the extent of injury to soft parts and bone and the condition of the clothing and skin of the patient. A wound sustained by a soldier dressed in mud-stained uniform in the well manured fields of Flanders inevitably became heavily infected unless treated energetically within a short time of wounding.

The bacteria which may be found in wounds are of many types, and may be divided into two groups. Group 1 consists of the following organisms, any or all of which may be present at the time of wounding: anaerobic spore-forming bacilli—for example *B. welchii*, *B. sporogenes* and *B. tetani*; pyogenic cocci—for example staphylococci, streptococci (haemolytic and non-haemolytic) and organisms of the *B. coli* group. At a later date Group 2, consisting of staphylococci and streptococci predominates, and may be the cause of septicaemia, in addition such organisms as *B. pyocyaneus* may be found as a secondary infection.

The spore-bearing anaerobes produce two conditions which are of extreme gravity and require special treatment—namely gas gangrene and tetanus—conditions which will be dealt with in detail later. The pyogenic cocci and organisms of the *coli* group etc. are more amenable to simple treatment, have mainly a local effect, although they may be the cause of a septicaemia,

and, with one exception, require no special measures apart from the routine treatment for all wounds The exception is the haemolytic streptococcus, which in the great war was the cause of septicaemia in innumerable cases and was then found difficult if not impossible to combat At the present time the introduction of the sulphonamide group of drugs has entirely altered the picture, and it seems probable that the use of sulphonamide as a prophylactic, as is the case already in civil compound fractures, etc , and for treatment when infection is established, will be of extreme value provided the drug is employed with care

TETANUS

The incidence of tetanus fell to such a very low figure in the great war after it had been decided that anti-tetanic serum should be given to every wounded man, however trivial the wound, that it is clear that the disease is largely preventable Infection is by means of spore-bearing anaerobic organisms which, if able to develop in a suitable environment, produce a toxin which eventually invades the central nervous system via the motor nerves The organism may be present in a wound without producing the disease Any type of wound, even the most trivial graze, if infected, may be the cause of tetanus , but punctured wounds, and wounds in which other organisms, which use up oxygen, are present, are particularly favourable to the development of the disease

PREVENTION

Experience in the treatment of wounds shows, first, that the more carefully the wound is treated in the early stages the less the liability to infection by *B tetani* , and, secondly, that the use of anti-tetanic serum in suitable doses is of indisputable value

Dosage of Antitoxin —The customary prophylactic dose for the majority of wounds is 500 U S A. units—a larger dose of 1,000 to 1,500 units being given in the case of severe wounds or when a wounded man has not been within reach of assistance for a

considerable time after being wounded. A larger initial dose was advocated towards the end of the war and it seems probable that a first dose of 1 000 U.S.A units in all cases would be preferable to the smaller standard dose of 500 units Tetanus spores are very resistant and may lie dormant in wounds for long periods, hence it is essential to repeat the injection of serum weekly for four weeks, and in addition a dose should be given subsequently if any further operation is to be performed involving the original wound area. This dose should be given eighteen to twenty four hours before the time of operation The danger of anaphylaxis is very small and will be still less now that the antitoxin is concentrated in a smaller bulk of serum.

INCUBATION PERIOD

The incubation period in cases which have not been given a prophylactic dose of serum shows considerable variation, onset of symptoms within twelve hours has been recorded and the first symptoms of the disease may be delayed for as long as twenty-eight days Taking an average it appears that in cases untreated by serum the onset of symptoms usually occurs in from seven to ten days. In cases treated by serum the onset is always delayed, its average time of appearance being approximately fourteen days The severity of the symptoms varies directly with the date of onset if symptoms begin within seven days of the injury a fatal result is almost inevitable the mortality diminishes with the delay in onset

SYMPTOMS

I do not intend to describe fully the symptoms of a developed case of tetanus these will be known to anyone who has seen such a case and they are adequately depicted in all textbooks. Certain of the early and premonitory symptoms require mention.

One of the earliest signs is anxiety The patient looks worried, his face is pinched the pulse is quick, the tongue tremulous and there is obvious deterioration of his general condition. The next phase is slight spasm of the facial and masticatory muscles slight stiffness of the neck, and at times some spasm of the

vesical sphincter With this there is often difficulty in swallowing fluids as well as solids Finally, well-marked trismus and risus sardonicus appear, with subsequently all the well-known generalized spasms of fully developed tetanus

In some cases, especially those with a delayed incubation period, the condition known as local tetanus may be observed In this condition there is localized stiffness and spasm of muscles in the neighbourhood of the wound Generalized spasms may follow, but in a considerable number of these cases generalization of symptoms does not occur provided additional serum treatment in large doses is instituted at once Another type of infection is cephalic tetanus, the cranial nerves being affected as a result of a wound of the face or head Facial palsy with spasm of the facial muscles is the principal feature; generalization of the disease is uncommon, and recovery is the rule

TREATMENT

Immediate isolation of the patient in a quiet room that can be darkened is essential Any sudden auditory or visual stimulus may invoke a spasm Doubts have been cast on the efficiency of serum once the disease has started, but my own feeling is that in large doses given subcutaneously, intramuscularly, intravenously, and intrathecally serum is definitely beneficial by its action in neutralizing further toxins liberated from the infected area Very large doses should be given in the following way On the first day, (1) intrathecally, (2) intramuscularly, (3) subcutaneously; (4) intravenously—15,000 U.S A units by each route This dosage should be repeated daily—with the exception of the intravenous dose, which it is safer to omit—until symptoms begin to abate The dose may then be reduced, but treatment by the subcutaneous and intramuscular methods should continue until all stiffness has disappeared The injection is comparatively small in bulk, there now being 1,500 U S A units approximately in 1 c cm of serum in the concentrated preparation This reduction in the amount of serum given diminishes the risk of anaphylaxis, but this danger must always be borne in mind when administering antitoxin by the intravenous route

extent that its action is inhibited and only starts again after *B sporogenes* has produced enough alkali to neutralize the excess of acid Infection by gas-forming organisms occurs, in almost every instance, primarily in muscle, and the virulence and extent of the infection depend on the integrity of the blood supply to the part Gas-forming organisms may develop in the pleural cavity or in a joint when blood is present, but under such circumstances show much less virulence Invasion of the blood stream is uncommon, and is usually a terminal event

THE CLINICAL PICTURE

From the clinical point of view a case of gas gangrene presents the following picture

The onset may be very rapid the earliest case I saw developed not more than three and a quarter hours after the receipt of the wound The average time of onset is probably about thirty-six hours, and development at a much later date has often been recorded. The appearance and condition of the patient are characteristic the skin is yellowish, the expression pinched, and the tongue dry, the pulse is rapid and poor in volume, and the blood pressure as a rule is low. The condition of the patient may be far graver than the nature of the wound would indicate

The wound itself presents certain definite features a characteristic smell resembling acetylene gas is to be noted on removal of the dressings, the skin edges show no reaction, and a thin discharge often containing gas bubbles is seen escaping from the wound

If a limb is affected swelling is present and a tympanitic note may be obtained on percussion In the late stages crepitation may be felt in the subcutaneous tissue In the early stages the skin of the limb is pale as a result of the swelling As the condition progresses the skin becomes yellow, purple patches then develop, with blebs containing blood-stained serum, and finally, when death *en masse* has occurred, the limb assumes an olive-green colour

When a wound is opened up or an amputated limb is examined

after removal, naked-eye changes in the muscle may be observed. The earliest change is in colour the normal purple-red of healthy muscle changing to a dusky red in more advanced cases the muscle becomes a brick red is friable and non-contractile and gas bubbles may be seen or felt in it. In the last stages the muscles become pultaceous and greenish black. The fact that at operation on a wounded limb non-contractile brick red muscle is found should at once suggest that gas gangrene is present even if it had not been suspected before On microscopical examination it can be seen that the muscle fibres are at first coagulated and separated from their sheath by a space presumably containing gas and toxic exudate and in the later stages both sheath and fibres are completely disintegrated.

The gangrene may be of two types (1) Massive gangrene involving the whole limb and practically always associated with injury to the main vessels of the limp (2) Group gangrene where a muscle or a group of muscles are affected the main blood supply being unaffected It is of interest that in this type of case the infection does not readily tend to spread from one group of muscles to another

TREATMENT

Prophylaxis by means of anti gas-gangrene serum or the use of this serum after the infection has been established is in my opinion of little or no value though it is obviously difficult to substantiate this statement fully in the case of prophylaxis. The giving of anti-gas-gangrene serum at the same time as anti tetanic serum is advisable therefore, and though it may do no good it can do no harm. The best form of prophylaxis is the early and careful débridement of the wound all dead tissue especially muscle of doubtful vitality being removed and the wound being left open for some days if there is obviously risk of severe infection. In established cases the line of treatment depends on the nature and extent of the infection. Where there is massive gangrene in a limb with damage to the main artery early amputation is essential. Such amputations should be well above the limits of the infected area if flaps can be fashioned

they should be ample, and it is advisable that they should not be sutured for some days Exposure of the stump to the air with the minimum amount of dressings is also of extreme value The immediate amelioration in the patient's condition after amputation for gas gangrene is most remarkable

In group gangrene, where a muscle or a group of muscles are attacked, resection of the affected area will often cut the infection short and save both limb and life I will give two examples of such cases to illustrate the method

Case 1.—This patient was wounded at 1 a m , the right leg being shattered in the lower third He was admitted at 3 30 a m , and a primary amputation was performed by equal lateral flaps in the upper third of the leg at 4 a m The flaps were lightly sutured and provision was made for continuous eusol irrigation All went well for twenty-six hours , the pulse then ran up to 120 (it had previously been 80 to 90), the tongue became furred, and the patient was drowsy and obviously very ill. On examination of the limb the front of the leg showed mottling of the skin, with swelling and a tympanitic note on percussion The patient was at once anaesthetized and the wound was opened up, when it was found that the entire anterior tibial group of muscles in the stump were brick-red in colour and non-contractile They were removed *en masse*, and the wound was left open and treated by continuous eusol irrigation After twenty-four hours the patient's condition improved steadily, and he was evacuated to the base nine days later At the first operation it was noted that the anterior tibial artery was occluded but that the anterior tibial muscles were apparently healthy and contractile , the arterial occlusion clearly predisposed to the development of the gangrene at a later date In this case it is doubtful whether the patient would have survived an amputation through the thigh Local excision of the infected muscle group gave him a useful stump with a normal knee-joint

Case 2 —This patient was wounded at 4 p m by a rifle grenade fragment and admitted three and a quarter hours later as a walking case When he arrived he was clearly very ill His pulse was 120, of poor quality , the tongue was furred and the

face pinched. There was an irregular entry wound the size of a threepenny piece on the posterior aspect of the right arm just above the internal condyle of the humerus there was no exit wound. The whole arm appeared swollen and was crepitant to the touch there was a tympanitic note on percussion. He was operated on at once, when it was found after excision of the wound of entry that the projectile was lying to the inner side of the vessels in the lower third of the arm. A second incision was made over the site of the projectile and subcutaneous tissue was found to be oedematous and the biceps muscle showed signs of gangrene The whole biceps was therefore exposed by a long incision and the inner half was found to be changed in colour and non-contractile the outer half of the muscle appeared to be normal. As the infection seemed to be localized to the inner half of the muscle this portion was excised in its entirety The wound was left open for seven days, and was then closed by secondary suture. The ultimate result was extremely satisfactory

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GUNSHOT WOUNDS OF THE CHEST[1]

By G E GASK, C M G, D S O, F R C S

In the latter years of the great war we saw many changes in the treatment of gunshot wounds of the chest During the first two years of war very little was done The usual treatment afforded was to put the patient to bed, give him some morphine and a cough mixture, and hope for the best If an empyema formed a portion of rib was excised and the pleural cavity was drained by means of a tube As might be expected, the mortality was great and in non-fatal cases convalescence was often prolonged

The reasons for the non-intervention were three First, experience of the South African War, where the ground was dry and clean and where wounds were largely due to rifle bullets, led our surgeons to the belief that chest wounds were best left alone, secondly, it was believed that it would be fatal to open up the chest cavity without the aid of some form of pressure chamber; thirdly, it was thought that handling of the lung would provoke fast and fatal bleeding Experience proved these assumptions wrong, and a complete change was made in our practice, not from the discovery of any new method, but by the application to these injuries of the general principles of surgery which govern the correct treatment of all wounds—namely, early mechanical cleansing by operation followed by early closure

TYPES OF WOUNDS

The types of wounds commonly met with in a casualty clearing station are as follows the through-and-through wound caused

[1] The substance of this lecture was presented to the ninth annual session of the Clinical Congress of the American College of Surgeons in 1918, and appeared in *Surgery, Gynecology and Obstetrics* in the following year

by a rifle bullet the through and through wound caused by a shell fragment the lodging wound with retention of a large foreign body the lodging wound with retention of a small foreign body and the open sucking wound of the thorax, with or without retention of a foreign body

CAUSES OF DEATH AND PROLONGED ILLNESS

If complicating wounds are disregarded the causes of death from pure chest wounds may be divided into three groups deaths on the battlefield or in a few hours after admission to a medical unit due to injury to large vessels or an extensive lesion which cannot be aided surgically deaths after forty-eight hours —these are almost always due to sepsis of the pleural cavity and its contents and deaths at the base after seven days. In the last group again the cause of death is almost invariably sepsis. Therefore the guiding principles in treatment of chest wounds, as in any other wound, must be the elimination of contamination before organisms have had time to invade the tissues.

CHANNELS OF INFECTION

Granted that the chief danger to a man wounded in the chest is infection, it is necessary to see how organisms reach the chest cavity The pleural cavity may be infected (1) by the missile and portions of the clothing or equipment carried in by it (2) from the wound of the lung in which a missile, a splinter of bone, or a portion of clothing may be retained (3) through the wound in the chest wall. A wound that opens direct into the pleural cavity through which air is constantly sucked, will always lead to infection and unless dealt with is often fatal. Further a wound, even of moderate dimensions, through which air is not being sucked unless adequately dealt with may suppurate in the course of a few days and if the thoracic cavity is not sealed off organisms gain entrance to the pleural cavity where they find the blood a convenient medium for growth This accounts for many cases which exhibit septic changes only after an interval of five or six days.

PRIMARY MEASURES

The principle to be aimed at, therefore, is the early mechanical cleansing of the wound, both of the chest wall and of the injured viscera, the evacuation of all foreign bodies and of effused blood from the pleural cavity, the repair or suture of the damaged lung, and the closure of the chest cavity by suture To arrive at this, when a patient suffering from a chest wound is admitted to a casualty clearing station he should be put to bed and allowed to rest undisturbed to recover from shock The only exception to this rule is when there is a large open blowing wound of the chest In such a case the opening is at once closed by temporary skin suture The relief given is immediate, and it is generally advised that a blowing chest wound should be sewn up at the earliest possible moment in the advanced medical units

Patients with retained missiles should be submitted to *x*-ray examination for information concerning the position and size of the foreign body, the existence and extent of haemothorax and pneumothorax, and the condition of the opposite lung, cardiac displacement, and movement of the diaphragm

INDICATIONS FOR EARLY OPERATION

These are as follows a ragged wound of the soft parts, bleeding from the parietal wound, compound fracture of the ribs, suction of air into the pleural cavity, retention within the chest of a large foreign body, great pain due to in-driven splinters of bone, rapidly increasing pneumothorax due to a valve-like opening into the pleural cavity which allows air to be sucked in and prevents expulsion, and a large haemothorax which cannot be evacuated by aspiration When none of these indications are present—that is, when the wounds of the chest wall are small and clean, such as those made by a rifle bullet, when the ribs are not splintered, when the foreign body retained is small—the patient is treated on general medical principles

TREATMENT BY OPERATION

The best time to operate is as soon as possible after the receipt of the wound, provided the patient has recovered from the initial shock. Patients bear operation well and take a general anaesthetic satisfactorily It is unnecessary to use any form of pressure chamber

Wounds of Soft Parts of Chest Wall —Wounds of the soft parts unless small and clean, should always be excised even if nothing further is done, because otherwise they suppurate and infection is liable to spread along the track of the missile into the pleural cavity

Fracture of Ribs —Excision of the soft parts leads the surgeon to the ribs. More often than not the ribs or scapula are broken, and, whether of not the chest is to be opened the splinters of bone should at least be removed ragged ends of rib cut cleanly off and all dead tissue excised

Thus the first step in the treatment of a chest wound is to make a careful complete excision of the parietal wound. In some cases this is as far as the surgeon should go Excision of the wound allows a thorough examination, which may reveal either a bleeding intercostal artery or a large hole hitherto unsuspected, leading into the chest, and a finger introduced into the pleural cavity may discover splinters of bone either free or sticking into the lung Such splinters ought to be removed for they play a great part in the production and maintenance of sepsis.

At this stage the case has been converted into one of open haemothorax. Two courses are now available to the surgeon he may do what is called the complete operation, opening the chest, repairing the lung, cleansing and closing the pleural cavity or he may content himself with the excision or with suturing the parietes after evacuation of the blood from the pleural cavity either by rolling the patient or by aspiration. The decision may be difficult. My belief is that if any operation is undertaken for a penetrating wound of the chest it should be done completely as yielding the best results in the long run

RETENTION OF A LARGE FOREIGN BODY

By a large foreign body is meant a shell fragment of about one inch by half an inch Such a fragment not only injures tissue but carries in with it fragments of clothing which unfailingly cause contamination Therefore it should be a rule that all large missiles be removed at an early date The operation may be done either by enlarging the original wound or by a fresh incision, and the surgeon is guided in his choice by the position of the missile relatively to the wound, as seen by the radiograph Where possible thoracotomy through the wound is preferred, but in any case the original wound or wounds must be completely excised A fresh thoracotomy may be done by resection of four inches of rib or by an incision in the intercostal space The easiest route is probably via the fifth rib in the anterior or mid-axillary line , through such an incision with the use of a retractor or rib spreader any part of the pleural cavity can be reached On looking into a chest thus opened the first thing seen is a quantity of blood the greater part of which is unclotted—at any rate during the first two or three days after injury This must be removed by mopping The cavity of the chest is now visible, the chief objects seen being the collapsed lung, the dome of the diaphragm, and the mediastinum The missile may be evident at once, but, if not, it may be sought by inserting the hand into the pleural cavity , if it is lying in the lung it can be felt with the fingers, and be removed either through the wound of entry in the lung or by fresh incision into lung tissue

Lung tissue may be excised without fear, because any fresh bleeding following incision is easily controlled by suture Continued bleeding from the lung is exceedingly rare *Arrest of bleeding follows spontaneously from collapse of the lung , and early operation within twelve hours after injury does not cause recrudescence of bleeding* The wound in the lung itself should be excised, when possible, in the same way as a wound of the soft parts—that is to say, it should be cleaned mechanically and sutured It should be sutured for two reasons first, because even if not completely freed from organisms there is evidence that the lung

is capable of dealing with a considerable amount of infection, as proved by the rarity of gas-gangrene infection, and, secondly, because restoration of function is hastened.

ABDOMINO-THORACIC INJURIES

Injuries involving both the chest and the abdomen are not infrequent, and may be either single or multiple. When a missile has traversed both chest and abdomen the diaphragm is necessarily injured, and abdominal viscera may herniate into the pleural cavity This is more often found on the left than on the right side, because on the latter the liver affords protection. The diaphragm can only be repaired efficiently from above therefore it is wise to open the chest first, replace the abdominal viscera, suture the diaphragm deal with the chest as already indicated, and then if there is evidence of injury to the hollow viscera laparotomy may be performed The passage of a small missile through the diaphragm may not necessitate repair in such a case with evidence of injury to hollow viscera, the abdomen is given preferential treatment.

HAEMOTHORAX

The question often arises as to the correct treatment for a patient with haemothorax of moderate dimensions and in whom there is no retained missile and no large wound of the parietes —that is to say a case of uncomplicated haemothorax. The majority of these cases recover with aspiration. A certain proportion however become infected. If it were possible to foretell which cases would become infected then there is no doubt that they would be operated on at an early stage the haemothorax evacuated, the damaged lung repaired, and the chest closed. So far as is known there is no way of foretelling this therefore, to prevent any possible infection it would be necessary to operate on every case—a course which is not advocated, seeing that many of these patients get well by themselves. The usual practice is to aspirate the haemothorax as completely as possible and make every effort to detect signs of infection at the earliest moment The only certain evidence of infection is either a

positive bacteriological finding or the removal of stinking fluid By clinical signs it is often possible to diagnose the existence of infection before organisms can be detected by the bacteriologist

The essential treatment, as soon as infection is proved or suspected, is to empty the chest of all blood and clots This cannot be done by aspiration, so open operation must be employed The common practice has been the resection of an inch of rib and insertion of a tube Provided the operation is performed within a few days after receipt of the wound it is better to do a wider resection, cleanse the pleural cavity, and close the chest, subsequently keeping the pleural cavity dry by aspiration This method offers the following advantages the chest may remain closed, the lung is allowed to expand and adhesions may form which will prevent complete collapse, even if the pleural cavity is subsequently drained, respiratory distress is much less with a closed chest, and if infection persists and the chest has to be drained it is very easy to take out a few stitches and insert a tube Drainage of a chest, like amputation of a limb, should be regarded as an admission of surgical failure

CONTRAINDICATIONS FOR OPERATION

These are shock and collapse, such as would be contraindications for any surgical procedure, small clean wounds without evidence of serious intrathoracic injury, and collapse of the opposite lung as indicated by inspirating retraction of the chest wall on the side opposite to the wound—in this case an anaesthetic on opening of the chest may be fatal

OPERATIVE TECHNIQUE

Thoracotomy through the Wound—The first essential is the complete excision of the wound, including the skin, muscles, and broken ends of rib This having been done, the chest should be opened with fresh instruments An incision is made from the edge of the wound through the skin along the line of the broken rib, either forwards or backwards, to obtain the best access to the cavity of the chest The muscles are incised down to the rib and retracted, and the periosteum incised along the

middle line of the exposed rib Along this line the periosteum is stripped off with a rugine A Doyen's periosteal rib elevator is then inserted and the periosteum entirely separated The bone is now cut through with a pair of rib shears or bone forceps and removed To allow free access to the pleural contents and insertion of the hand it is necessary to take away four inches of rib The posterior layer of periosteum of rib with the parietal pleura attached is next incised with a pair of scissors along the middle of the gap Then a retractor or rib spreader is inserted and the chest opened widely

Thoracotomy by Fresh Incision—As previously stated this operation may become necessary when thoracotomy through the wound will not allow access to the injured portion of the lung—for instance, when the wound is in the lower and posterior part of the thorax and the foreign body near the hilum or in the upper lobe of the lung Resection of four inches of the fifth or sixth rib in the anterior axillary line gives a good exposure of the thoracic contents, and if there are no other considerations this is probably the best and easiest route to follow It has to be remembered, though that if drainage of the pleural cavity has to be performed later on it cannot be done effectively through this incision Therefore if the nature of the wound and missile is such as to indicate probable future infection it may be advisable to choose a lower rib and make the incision more posteriorly A six inch incision is made along the line of the selected rib and continued down to the periosteum which is stripped off the anterior surface with a rugine With rib elevator and shears four inches of the rib are resected. The posterior layer of periosteum with the parietal pleura attached is then incised along the whole length of the middle of the gap and the retractor or rib spreader inserted.

PROCEDURE WITHIN THE THORACIC CAVITY

After the chest has been widely opened either through the wound or by fresh incision it is advisable to remove the blood from the pleural cavity—first, because it is easier to see what has to be done and, secondly because removal of the blood

relieves respiratory difficulties by lessening pressure on the mediastinum The blood can be removed by rolling the patient on to his side Probably, however, it is better to do it by swabbing with gauze and scooping out the clot with the gloved hand, less disturbance is caused to the patient by this method. This done, the gloved hand should be inserted into the pleural cavity and swept around in order to detect and remove any splinters of bone which may be lying free, or the missile and portions of clothing These are most likely to be found in the pleuro-diaphragmatic reflexion. Next, the foreign body, if retained in the lung, may be detected by the fingers, and with the aid of two pairs of lung forceps the affected area is brought into the opening of the chest The lung can be handled as easily as a coil of intestine, and without causing a great fall in blood pressure

TREATMENT OF THE WOUNDED LUNG

A foreign body, when present, seems generally to lie near the surface of the lung, and can easily be removed; if necessary, a small incision may be made through the lung substance The hole in the lung should now be explored for splinters of bone and shreds of clothing, and cleansed as far as possible by swabbing When there is a large ragged wound, and it is anatomically possible, a wedge of lung may be removed or the edges of the hole clipped with scissors In any case, whether the wound is excised or not it should be closed by catgut sutures in either one or two layers. according to the depth of the wound Bleeding is easily controlled by such suture

CLEANSING OF THE PLEURAL CAVITY

In most cases it is only necessary to cleanse the pleural cavity by swabbing it dry and clean. If, however, there has been much soiling it is advisable to wash it out with either warm saline or eusol In any event the chest should be left dry, an essential factor in the early expansion of the lungs

CLOSURE OF CHEST AND POST-OPERATIVE TREATMENT

Whether the operation has been performed through the wound or by fresh incision the chest should always be closed. The

relief afforded is instant and marked An attempt should be made to repair the chest wall in layers—pleura to pleura muscle to muscle and skin to skin. Where a large hole has been blown through the chest wall it may be impossible to get the edges of the pleura to meet, in that case muscle should be made to cover the gap even if a flap has to be cut Finally the skin should be closed by interrupted sutures In the majority of cases healing will be by primary union

Regular post-operative aspiration is generally required to keep the pleural cavity dry for after a big operation there is usually a fluid exudate, which if not removed may become infected.

WAR SURGERY IN SPAIN

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It is my purpose here to give an outline of the practical lessons to be drawn from the most recent available experience in war surgery, both in the field and on the home front It is of course impossible even to touch on all the developments that the well-organized Republican Medical Service in Spain has introduced into the practice of war surgery I shall therefore limit myself to certain questions which have a general importance and in which I had an experience sufficient to enable me to give a personal, not merely second-hand, opinion. I will touch on the present position in regard to three main topics. (1) the general problem of wound excision and primary suture, and the conditions favouring its success; (2) the treatment of septic wounds and of anaerobic infection: and (3) conservative surgery of limbs

WOUND EXCISION

Wound excision has completely replaced all attempts at local disinfection. This principle which emerged from the last war, is now so generally accepted in war surgery that it would not need further mention except for the fact that in civil accident surgery it is by no means yet universally adopted. We may therefore unfortunately expect that the ancient practice of the casualty departments of many hospitals will be carried over into war surgery, in the first few weeks at least We should of course insist on a proper standard of treatment of civil accidents in peace-time if we wish to secure the best treatment in war-time

Success after primary wound excision consists in the avoidance of sepsis and especially of gangrene. The chief factor in failure

lies, I believe, not in a careless technique of asepsis, and certainly not in any possibility of antisepsis but in the persistence in the wound of non-viable tissue or of gross foreign matter It is in fact not merely the infecting organisms but their breeding ground that we must remove For this reason a haematoma in a war wound is a potential danger, and must never be left unoperated For this reason, too injury to the femoral or popliteal artery is in my opinion a peremptory indication for immediate amputation if there is extensive laceration or a fracture.

PRIMARY SUTURE

Once the excision is as complete as possible, and providing the case has come to operation within twelve hours or in certain cases up to twenty four hours, there is no contraindication to primary suture if certain conditions are fulfilled. The first of these is that the skin edges can be brought together without tension sometimes a lateral incision, on one or both sides will make this possible The second is that the case need not be further evacuated, but can be retained immobilized and under constant observation.

If the skin edges cannot be brought together without tension, suture is useless and will always break down. If the case cannot be retained for the critical post-operative period, suture is dangerous and should never be performed. I want especially to stress this point, because there seems to me to be a not very well considered readiness to advise primary suture after excision on the assumption that this will be the routine at casualty clearing stations, from which the majority of cases will immediately be further evacuated If this is done I feel perfectly certain that our Spanish experience will repeat itself and that surgeons in base hospitals will be removing sutures almost as a routine as the cases arrive with severe sepsis or gangrene, while the surgeons in the casualty clearing stations will continue happily unaware of the lack of success of their operative efforts. The result might well be an undue reaction against primary suture as such, though it is of course the very best method available if the proper precautions can be taken. Further there are certain cases which

demand primary suture as the only method of saving life or limb These are

1. Open pneumothorax, a class by itself requiring operative intervention at the earliest possible moment

2 Penetrating head wounds The results when the ventricles have not been penetrated are so excellent with early operation and primary suture without drainage that no case should ever be left unoperated over the twenty-four hours The scalp should always be sutured and the patient be given a period of ten days at least, twenty days if possible, of undisturbed post-operative rest Without such treatment the mortality from such wounds, when the dura has been penetrated, approaches 100 per cent

3 Penetrating wounds of joints form the third class of case that require excision and primary suture The results after such treatment are again so excellent, and the consequences of any other treatment are so serious, that these cases should be brought into the class of urgencies for both operation and subsequent retention in the hospital of operation

A few words on the technique of suture I am strongly of the opinion that no internal suturing should be performed under any circumstances—neither of nerves nor of tendons nor of fascial layers At most it is sometimes necessary to tie off an artery I never sutured the capsule of any joint, and the results were uniformly good. With this technique the skin only is sutured, and it is sutured very carefully with interrupted sutures to secure exact apposition This is the technique recommended by Böhler. His experience is overwhelmingly greater than that of any British surgeon can be, owing to our almost complete lack of organization of traumatology as an independent branch of surgery The question cannot of course be regarded as settled. But it seems to me that surgeons who recommend internal suture of contaminated wounds should give us the practical experience on which they base their view.

If the incidence of infection with this technique is even appreciably lower than after suture by layers, or of nerves and tendons, then such internal suture should be avoided, since once the

wound has healed by first intention a secondary aseptic suture of nerves and tendons is easy and without risk whereas if infection supervenes not only is the primary suture of nerves and tendons lost but there will be both sloughing and the subsequent development of much scar tissue

With regard to the sometimes recommended partial suture with a few 'situation sutures' only I can see nothing to recommend it. Either we hope to obtain healing by first intention, in which case we should suture completely and carefully, or if we think we are not likely to obtain healing by first intention we shall do better to leave the whole wound fully open without any suturing at all.

THE QUESTION OF DRAINAGE

It is now generally agreed that in certain situations drainage after primary suture should be avoided these are the peritoneum, the skull and brain the joints, and compound fractures where primary suture is attempted It must be stressed emphatically that Spanish experience fully confirms the inadvisability of draining in such cases But this leads us to question the advisability of draining at all where no sepsis is established as after a primary suture Drainage by strips of gauze has to be mentioned only to be condemned Such drainage acts merely as a plug and if left for more than forty-eight hours makes sepsis a certainty Dependent drainage is usually advised if it is thought that haemostasis is imperfect. Personally I would advise firm bandaging maintained for about six hours, which is sufficient to still any oozing

So far therefore, the wound is excised as completely as possible and the skin carefully sutured without drainage but only if the conditions enumerated above are fulfilled Firm bandaging has been applied to stop oozing but this is in most cases only the first half of the operation although the tradition that the surgeon's essential task is over once he has finished stitching is so deeply rooted in most that the second half of the operation —the task of providing rest for the wound—is usually relegated

in textbooks to a simple statement such as " the limb should be placed on a skeletal splint ".

CONDITIONS ESSENTIAL FOR SUCCESS IN WOUND TREATMENT

The surgeon who desires success in accident work—and war surgery is, after all, only a special and horrible form of accident surgery—must learn early the fundamental lesson of the great orthopaedists, of Robert Jones and of Bohler, that operative intervention is but an item in the treatment. Success in wound treatment depends on providing the optimal conditions for the injured tissues to undergo the spontaneous process of repair The first part of the treatment consists in the apposition of live tissue to live tissue, after the removal of all foreign, dead, and dying matter The second part is the provision of rest for the process of repair and to overcome the infection which is almost inevitably still present The conditions necessary are : immobility of the injured parts in relation to one another, a good blood supply, and the avoidance of all that hinders rapid tissue metabolism This requires exact methods of immobilization in all severe limb injuries, even when a fracture is not present The technique of immobilization is no more to be learned from lectures or textbooks than is the technique of operation It needs practical experience For this reason alone, since limbs are concerned in 70 per cent of all war injuries, it is essential that the war-time general surgeon shall have had personal experience in the modern treatment of injuries in peace-time

The second condition required by the freshly operated wound is a good blood supply and the reduction or avoidance of oedema Elevation is therefore essential Oedema is always present at first, the onset being fairly rapid and inevitable after the injury But it is quite certain that the disappearance of this initial oedema is the best possible sign of success in treatment and that its persistence is invariably a sign of at least relative failure.

There is a third main principle in the post-operative treatment of wounds—non-interference In this the Spanish War marks a definite advance Not, of course, that the idea is at all new The Winnett-Orr operation, the Dickson Wright treatment of

varicose ulcer and the occlusive treatment of septic burns are but a few examples of a general tendency to realize that the surgeon's task is to assist tissue repair that is trying to develop quite independently of any efforts on his part Observing this principle of non interference, there are two alternative methods available. One is that of open wound treatment with no dressing whatever This method is applicable whether the wound has been sutured or not. The Catalan school of surgeons, strongly under the influence of Böhler, applied this method on a very wide scale The results are so excellent that I feel quite certain that it is merely a matter of time until this becomes a generally recognized standard treatment in casualty work.

There is however another method which also gave such excellent results in Barcelona that it is a serious rival to open wound treatment That method is the closed plaster cast applied to a fresh wound with or without petroleum jelly This is not so simple as open wound treatment and needs discussion. In the first place it is evident that if primary suture has been performed there is little advantage in a closed cast, but considerable danger In these cases it is clear that a large window should always be cut immediately with open treatment of the sutured wound But there remains a number of cases when suture cannot be performed and for these the closed plaster is the ideal form of treatment. The conditions for its application are first, that a complete wound excision must have been performed and, secondly that the conditions are the same as for wound suture the wound must be fresh—in general under twelve hours—and show no signs of infection already developed. This method may however be permissible for cases requiring further evacuation if proper precautions are taken for observation of pulse and temperature together with elevation of the limb during transport.

ORGANIZATION OF SURGERY IN WAR TIME

I will now mention two principles that touch the organization of surgery, especially of the first operative intervention, in war time The principle governing field surgery is, of course that

the wounded must be got away from the front as far and as fast as possible, that absolutely nothing must be allowed to interrupt the flow of casualties to the rear, even if this means some loss of lives that might have been saved under peace-time working conditions For this reason the casualty clearing station was developed near enough to the front to enable the first operative intervention to reduce enormously the incidence of severe sepsis and gangrene, yet inevitably also too near to the front to permit the majority of cases to remain there On the home front, however, conditions will be different It will remain absolutely essential to evacuate casualties very rapidly, and not to retain any save untransportable cases in the danger areas This is in fact proposed in the present Emergency Hospitals Scheme [1] For its successful working rapid transport will be essential, and for this purpose Spanish experience suggests the great advantages of rail over road transport [2] In any case it is greatly to be hoped that those responsible will take steps to ensure the effective carrying out of the Ministry of Health's advice in regard to pre-operative evacuation from danger areas, especially in view of the enormous numbers of casualties which are expected during the first few weeks of a war, owing to the almost entire absence of prophylaxis in the most dangerous areas

The pre-operative evacuation of casualties from the danger areas will make possible the observance of two principles (1) that all cases do much better if they can be given complete rest for the critical post-operative period, (2) that Robert Jones's principle of continuity of treatment and of surgical responsibility shall be achieved from the very start I think the importance of this second factor cannot be overestimated I cannot forbear to mention one matter of the highest importance in effective evacuation—the standardized stretcher and stretcher fitting, so that the wounded person never leaves the stretcher he or she is

[1] *Emergency Medical Services Memorandum* No 2 Emergency Hospital Organization Issued by the Ministry of Health Section 7

[2] In Catalonia, during the battle of the Ebro special hospital trains brought wounded to Barcelona for operation, and the system worked successfully The French army had already done the same thing in 1918, bringing wounded to Paris for operation.

first laid on until the operating table is reached The stretcher may often with advantage even be laid on the operating table.

After this excursion into the organizational field we will return to surgical matters, and consider the present position of the treatment of sepsis.

TREATMENT OF SEPTIC WOUNDS

Prophylaxis we have already dealt with. Treatment has radically altered since the days of the war of 1914–18 The advocates of irrigation now recognize that it is the mechanical washing far more than the action of the antiseptic that is respons ible for any improvement' I am boldly going to say that I doubt if irrigation will long survive at all. The principles of treatment are still as for a fresh wound—removal of foreign matter and non viable tissue if not already done followed by immobilization elevation and non interference To secure the latter open wound treatment is ideal. For the removal of non viable tissue in an infected wound maggots are unsurpassed and I hope this method will be developed extensively All this remains, however in most cases insufficient. Free drainage of pus is essential, and the simplest and surest way to obtain this is by adequate and careful, but liberal, counter incision with the insertion of soft corrugated rubber drains for a few days only Perhaps one should add the further instruction not to get worried, and to remember that the soundest criterion is this Is the patient in pain? If he is, treatment has been inadequate and must be improved. But if he is free from pain, probably all that is needed is a little patience. And I would stress both how important is this criterion of pain, and how well pain can in most cases be rapidly eliminated by correct treatment. It should also be stressed that morphine exists to be given not merely to be withheld. A good surgeon will in these cases give morphine freely but will also be able to cease to give it within a few days. Where the treatment is grossly incorrect, and the pain consequently severe no amount of morphine will control it and yet the patient will become an addict, however sparingly the drug may be given if he survives that long

without any general toxic effects In other cases a very localized infection without any massive gangrene can lead to death in five to eight days, with a toxic jaundice and confluent broncho-pneumonia. Further, it must be remembered that metastasis is very apt to occur This is the reason why it is so dangerous not to amputate immediately a lower limb that has lost its blood supply Other metastases occur in cases of gangrene the organism in the new focus not necessarily being an anaerobe. For instance the leg of a Spanish soldier aged 35 was amputated in guillotine fashion above the knee for gangrene of the leg The open stump never showed any sign of infection yet the temperature rose steadily over several days until finally jaundice developed and vomiting started A subphrenic puncture on the right side drew thin stinking pus a rib resection was performed in the expectation of finding a subphrenic abscess but there was no sign of one A needle was inserted into the liver and about 40 c.cm. of pus withdrawn. A rubber drain was inserted for twenty four hours As the vomiting continued three litres of glucose saline were given intravenously with some insulin. The vomiting ceased at once and the man made an uninterrupted recovery, no further pus coming from the incision which healed rapidly Facilities for a culture of the metastatic organism were not available but it was certainly not an anaerobe, as there was no gas escape on entering the abscess.

A further fact worth mentioning because not often found in what first-hand literature there is on gas gangrene, is that severe anaer obic infections almost invariably involve bones. In fact, if a local ized anaerobic infection develops in a wound diagnosed as of soft parts only an unsuspected bone injury will often be found. Such cases are apt to be dangerous, and require very radical opening

With regard to treatment amputation is *not* indicated except in cases of massive gangrene In these cases amputation must be performed without even half an hour's delay and accompanied by massive intravenous infusion, as the blood pressure will already be very low In other cases the wound must be thorough ly opened up and all necrotic tissue removed. The wound is then left fully open. The results of treatment on these lines at

the Lina Odena Hospital for Gangrene in Madrid were remarkable, with only some 15 per cent mortality Serum was used, especially intramuscularly, in the vicinity of the infection Employing a French polyvalent serum, I also had the impression that this serum was definitely antitoxic and that it was more useful given locally Finally, it may be stated that the incidence of gas gangrene is heavier in the lower limb than in the upper limb, and also, it would seem, more dangerous

CONSERVATIVE TREATMENT OF INJURIES OF THE UPPER LIMBS

I will now say a few words on conservative treatment of severe limb injuries In the upper limb there is almost never an indication to amputate Cases, of course, frequently arrive at the casualty clearing station with the limb already gone, but during my eight months at the front I amputated only one hand, or, rather, a few remnants of what had been a hand It is perfectly feasible, and even easy, to save an upper limb which may be almost completely severed If the neurovascular bundle in the arm is intact a very good result can be confidently expected The whole shaft of the humerus may be shattered into a multitude of fragments, and yet an excellent result be obtained That a very large bone defect is not a serious matter was illustrated by a radiograph which showed a four-inch tibial graft comfortably replacing almost the whole lower half of the shaft of the humerus Function in this case was perfect except for some 30 degrees limitation of extension at the elbow, due to a twelve-months delay in the case coming to be grafted

To obtain good results in severely shattered limbs all that is necessary is to apply the three general principles mentioned in the introduction on wound excision—namely, immobilization, elevation, and non-interference—after, of course, thorough and careful excision But it is precisely for such cases that the immediate post-operative use of plaster of Paris is essential As this method of treatment of fresh wounds, irrespective of bone injury, is little known in England, a case history may be worth giving by way of illustration

Pedro, a Spaniard aged 22, arrived at the C C S in February

bandages Lack of familiarity on the part of surgeons with this technique may account for some of the existing opposition to the wholesale use of plaster in war-time On the other hand, an ignorant use of this method will lead to wholesale ischaemia and gangrene The obvious solution lies in the systematic peace-time training of future war surgeons in modern methods of traumatology

Both immobilization, in the case of injuries to the arm and shoulder, and elevation, in the case of arm, forearm, and hand, require an apparatus for abduction of the limb There are two fundamentally different methods of obtaining this abduction Each is in my opinion necessary, the indication for the one or the other depending on the type of case The first is a thoraco-brachial plaster spica This was the standard treatment popularized by Bastos in Madrid and later brought to Barcelona by D'Harcourt and others Bastos's paper on war-time fractures of the humerus should be consulted (*Revista de Sanidad de Guerra*, No 2, 1937) The essential principle is that even infected fractures of the humerus are found to do very well in a closed plaster, even without any Winnett-Orr operation before its application However, it has to be recognized that this is not always the case, and that open treatment is sometimes essential For such cases the abduction splint popularized by Böhler is essential There is, however, nowadays not the slightest indication or excuse for any other form of splinting of the upper limb for injuries down to and including the elbow These two forms are adequate for all and superior to any other What must be stressed is the difference between the two, as this is not always fully appreciated

The thoraco-brachial plaster is applied with the homolateral shoulder dropped, and the arm abducted to 45 degrees only, neither more nor less In this position reduction of displacement is excellent, and the only disadvantage is that the shoulder is almost completely immobilized in a position which may make subsequent full abduction difficult to restore Otherwise the method gives excellent results for severe comminuted and infected fractures of the humerus, for which absolute immobility is essential

The abdnction splint, on the other hand is applied in an entirely different manner It is applied with and keeps the homolateral shoulder raised and is failing in its function if it does not do this effectively and permanently for so long as it stays in use It is essential that the shoulder should be kept raised, as otherwise the npper fragment is pulled down by the pectoral, and considerable angulation results What is even worse, the splint becomes at the same time a drag on the limb instead of a support for it and non union is quite likely to occur In an infected case a chronic osteomyelitis will develop

With both methods the arm must of course be brought forward to a line forming an angle of 45 degrees with the sagittal plane This position is in the case of a plaster jacket easy to retain In the case of the abduction splint it is much more difficult To obtain increased stability the Barcelona surgeons were in the habit of fixing the splint to the body not with calico bandages but either with a few plaster-of Paris bandages or with starched crinoline bandages, which are almost as effective and are lighter The lightness of the abduction splint, made of well padded Cramer wire is one of its advantages over the plaster spica Its other advantage is in the retention of partial mobility of the shoulder joint. Its disadvantage is that it does not give quite such good immobilization and is more difficult to apply It is to be noticed however that both appliances allow the patient to be ambulant within a few days of his injury if his general condition permits but their greatest merit is that they assist in an almost complete disappearance of that scourge of war hospitals—chronic sepsis. Very large stocks of Cramer wire should be prepared for war time use It is cheap simple adaptable and clean.

Operation for Severed Tendons

Before leaving the subject of the npper limb I will mention here a little operation which has proved useful for severed tendons, and which provides, I think for the first time a useful function for that bugbear of plastic surgery scar tissue It has already been mentioned that when a tendon has been severed it is useless

of sepsis in all the survivors, who were evacuated to base hospitals with normal temperatures and no signs of bone infection. Unfortunately I cannot claim, as I at one time thought I could, that none of these cases developed an osteomyelitis, because I subsequently saw a troublesome osteomyelitis develop in a supracondylar fracture after one month of apparently perfect recovery under traction. However, it is clear that early immobilization in an efficient form does give astonishing freedom from bone sepsis

On the home front it is clear that all fractured femurs should be evacuated at once on a Thomas splint to a specialized base hospital, which they should reach within twelve hours, without change of stretcher. Operative intervention and immediate skeletal traction would be effected at this specialized base hospital

Under field conditions it is of course impossible to achieve this I would suggest the treatment of fractured femurs under skeletal traction for some ten days at an advanced base hospital, reached within twelve hours normally, if need be up to twenty-four hours Spanish experience shows that this will normally secure freedom from infection. The limb would then be placed in plaster, applied under traction with hip and knee flexed and under a spinal anaesthetic; the patient can thus be transferred safely and comfortably to a permanent base, where the plaster could if necessary be removed and traction re-applied.

Another article in this series stresses the inadvisability of attempting to be too conservative in cases of severely shattered lower limbs Spanish experience confirms this advice, but also has established the fact that severe shattering or defects in the shafts of the long bones is never in itself an indication to amputate. The methods of Winnett Orr, and the development of these methods for the treatment of fresh wounds and compound fractures by Trueta have made it possible and even easy to ensure the spontaneous restoration of the most severely depleted tibias Severe muscle defect is now a much more serious matter than any damage to a long bone

The treatment of wounds involving fractures of the tibia, and of tibia and fibula, by means of radical wound excision and a closed plaster cast can now be regarded as becoming standardized

The plaster should be applied with the limb held on a Böhler lower limb screw traction apparatus Fractures of the leg bones should never be treated with traction without a plaster cast supported on a Braun splint It is usually best to insert a pin through the crest of the tibia leaving it for about three weeks The average case can and should begin to walk in four to six weeks in a weight bearing plaster—no crutches allowed In general it may be said that limb injuries of all kinds have become far more ambulant and much sooner ambulant than was the case in the war of 1914–18 This is especially due to much more efficient methods of immobilization which by giving real immobility to the wound allow of mobility to the man Fractures of the humerus, compression fractures of the spine fractures of the tibia and fibula and foot injuries are all examples of this. With such treatment atrophy and oedema of the foot in leg injuries completely disappear It is especially important that injuries to the metatarsals should be well plastered and the patients be got walking early

Wounds of the knee-joint present certain special features First in the case of no other joint is prophylaxis so important Excellent results are given by early excision with suture of the skin only without drainage followed by immediate temporary immobilization on a Braun splint under slight traction (2 kg)

In a few days, when danger of septic arthritis is over any fracture of the condyles is treated as a closed fracture If sepsis is established lateral drainage of the joint as advocated by Mitchiner is the first step but is often insufficient, especially if there is extensive comminution of a condyle In the latter case the most radical excision is necessary to save the limb for this a ruthless exposure is necessary and in fact has no disadvantage since a good arthrodesis is the best result that can be hoped for A standard treatment has not yet been achieved for these very difficult cases but I am fairly certain that the treatment when it does become standardized, will include immobilization in plaster-of Paris in preference to attempted immobilization under traction, which is inefficient and in my experience, gives inferior results

GUNSHOT WOUNDS OF THE UPPER EXTREMITIES

By CLAUDE FRANKAU, C B E, D S O, M S, F R C S

In the treatment of gunshot fractures of the upper extremity several points require special attention (1) As regards the wound itself, excision of the track may be extremely difficult in the forearm owing to the close apposition of tendons to the bone and the limited space available This can be overcome to a certain extent by free skin incision (2) Bone fragments can be more freely removed in fractures of the shaft of the humerus than in those of the lower extremity, as shortening in the upper limb is of no great importance Apposition of the two ends of bone is, of course, essential after removal of fragments In the case of the radius and ulna it seems that removal of small bone fragments, which in all probability will necrose, is preferable to their conservation, as any gap can be filled in later by grafting (3) Nerve lesions are more common in the upper than in the lower limb, and are of greater importance Their early recognition is essential (4) The most conservative attitude must be adopted as regards amputation, since the replacement of the upper limb by any apparatus is but a poor substitute for the natural limb, however deformed

Fractures may be divided into four groups of the shoulder girdle of the upper arm , of the forearm , of the wrist and hand

FRACTURES OF SHOULDER GIRDLE

Gunshot wounds of the clavicle rarely come under treatment, as the injury is likely to be fatal, either from involvement of the subclavian vessels or of the lung If no such complication obtains, after excision of the wound and removal of any sharp spicules of bone the case should be treate[illegible] ordinary lines

is, by Sayre's method or by a Hey Groves splint There is remarkably little disability after removal of large portions of the clavicle Fractures of the scapula not associated with a chest wound or with an injury of the upper end of the humerus and shoulder joint are so uncommon that no special mention need be made of them.

FRACTURES OF THE HUMERUS WHERE THE SHOULDER JOINT IS INVOLVED

Here one point is of special importance in a considerable proportion of these cases the projectile may have entered the chest cavity and this should be suspected where only a wound of entry is present For first aid treatment nothing more is needed than a bandage fastening the arm to the side and a sling At the casualty clearing station, after excision of the wound and treatment of the joint cavity bone fragments are removed as conservatively as possible since a flail joint is of much less value than a joint ankylosed in a good position. Provided the situation of the wound allows it a Thomas splint with an extension is the most useful for transport purposes Where the wound is too extensive to admit of the use of the Thomas splint the patient can usually be transported in comfort with the arm bandaged to the side

At the base, fixation of the arm in an abducted position with extension is essential. The extension may be taken by means of strapping applied just above the elbow or by means of a pin or wire through the olecranon, the forearm being flexed at the elbow and slung from a Balkan beam by this latter means movement of the wrist joint and elbow joint is possible As ankylosis is almost inevitable in cases of severe comminution the optimum position should be aimed at from the first—that is, abduction to 60 degrees with a few degrees of external rotation and with the elbow slightly in front of the coronal plane

FRACTURES OF SHAFT OF HUMERUS

Usually these wounds are associated with considerable comminution of bone and in many instances injury to the musculo-

spiral nerve or brachial artery In the front area, after applying a dressing, the limb may be bandaged to the side, the forearm being supported by a sling or bandage , this method is applicable to most cases, except those fractures just above the elbow-joint, for which a simple splint such as an internal angular is desirable

At the casualty clearing station the wound is excised in the routine way, careful examination for nerve injuries having first been made For transport to the base a straight Thomas splint is usually satisfactory, but it must be remembered that this method does not as a rule give satisfactory alignment in fractures of the lower third when the forearm is extended, and it should only be regarded as a temporary measure At the base the straight Thomas splint may be retained to support the upper arm, extension being obtained by pin or wire traction through the olecranon and the limb being slung from a Balkan beam in an abducted position with the forearm flexed This method allows of free access to the wound and good alignment of the fragments, and, further, finger, wrist, and elbow movements may be started at an early date As soon as the condition of the wound allows the limb may be put on a bent Thomas arm splint, which allows the patient to be up, or a plaster-of-Paris splint may be employed

Fractures involving the elbow-joint —These are commonly of a severe nature, with much bone injury and often with associated nerve-trunk injuries In the forward area an internal angular or Jones interrupted arm splint should be applied for transport At the casualty clearing station the wound is treated in the ordinary way , small detached fragments of bone are removed, but great care should be taken to preserve as much bone as possible, and especially the olecranon process The joint cavity is then irrigated and closed by suture of the capsule or by the use of fascial flaps For transport to the base a straight Thomas splint with an extension, the hand being in full supination, is the most suitable method

At the base the straight splint should be used for a limited period only—not more than fourteen days—owing to the difficulty in obtaining flexion subsequently if the arm is kept extended

for too long a Jones interrupted arm splint may be used or the limb may be supported without splinting on pillows the forearm being flexed to a right angle at the elbow Ankylosis or greatly restricted movement is almost inevitable the limb therefore must be put in the most useful position at as early a date as possible In most cases flexion to 75 degrees with the hand midway between pronation and supination is the optimum position Formal excision of the joint is rarely called for, but may be necessary in severe infections to save the limb

FRACTURES OF FOREARM

One or both bones may be involved muscles and tendons are often severely damaged and nerve injury is not uncommon The preservation of a useful limb therefore presents very considerable difficulty For transport to the casualty clearing station immobilization on a straight splint supporting the hand as well as the forearm is sufficient At the casualty clearing station, after the routine treatment of the wound bone fragments especially those driven into muscle should be removed It is better to leave a large gap between the bone ends and a wound that heals readily than to leave small fragments of bone which inevitably necrose and delay healing for months The gap can subsequently be filled by bone grafting which was carried out successfully in many of these cases Repair of divided nerves and tendons should be effected if possible though this is not often the case

For transport to the base a straight Thomas splint with a strapping extension the forearm being in full supination is the best method At the base the straight Thomas splint may be used for the first fourteen days, after which time a bent Thomas splint may be applied Plaster of Paris, though of value later is not very suitable in the early stages owing to the difficulty in controlling the fractured bones without extension

FRACTURES OF WRIST AND HAND

Wounds of the carpus are often explosive in type with a large exit wound and with great damage to tendons the wrist joint

is commonly involved In the forward area, after dressing, a simple flat splint is applied At the casualty clearing station, when the wound has been excised, the carpal bones are carefully examined, and any that are badly comminuted are removed Closure of the capsule of the wrist-joint is usually impossible, and the wound cavity is best packed with gauze smeared with petroleum jelly Primary amputation should only be carried out where tendons, vessels, and nerves have been completely destroyed

Splinting of wrist-joint injuries with extensive wounds is difficult, but for transport to the base a simple flat splint extending from the roots of the fingers to the elbow-joint is generally adequate At the base, provided healing is proceeding satisfactorily, the hand and wrist should be put on a Jones cock-up splint or in plaster the wrist being dorsiflexed On the whole this type of wound gives poor results, but even if partial use of one finger and the thumb can be obtained this is better than any artificial limb

INJURIES OF THE LOWER LIMB

By ST J D BUXTON, MB BS, FRCS

During the last war it soon became clear that no effort should be spared to find any method of treatment that would lessen the permanent drain upon the nation caused particularly by gunshot wounds of the lower limb General principles became established, and of these perhaps the most important was the early operative treatment as the only means of avoiding those terrible septic complications that are the cause of the majority of bad results. Hence the really important surgery is done if possible at casualty clearing stations and not at the base But the responsibility of those concerned with the after treatment is not less than that of the operator Obviously the title of this lecture includes many injuries occurring in times of peace The treatment of these will not differ in times of war excepting that greater delay in transport is liable to occur and evacuation will necessitate changing the patient's doctor probably several times

FIRST AID TREATMENT

One cannot escape the impression that those who survive a bombardment such as is now possible from the air may receive wounds of greater severity than the average wounds sustained during 1914–18 Wounds of the soft parts may be so slight that the injured can hobble to an aid post, or so severe that traumatic shock is serious. In fact, an extensive injury or multiple wounds of the thigh may be accompanied by as much shock as with a fractured femur or mutilated leg Haemorrhage will aggravate such a condition

The aid post or immediate treatment will consist sometimes in dealing with haemorrhage and always in the application of a dressing (first-aid or shell) Immediate evacuation of the severer

appear normal and when there is no swelling or lymphatic infection This state may last for twelve or twenty-four hours, but seldom longer During this period large incisions, with the removal of foreign bodies (such as clothing) and projectiles, are not dangerous After this time similar incisions, particularly in muscle, will lead to an aggravation of local and general signs and usually septicaemia

After clinical and radiological examination the patient is anaesthetized and an extensive area of skin shaved and cleaned If the wound is of soft tissues only, and can be excised without damage to blood vessels and nerves and without making a very large wound, this should be carried out, it may be possible in the gluteal area and on the outer side of the thigh, but seldom in the calf If incision cannot be done, the skin edges, underlying fat, and maybe aponeurotic tissue are excised and the opening of the wound or wounds enlarged in the long axis of the limb The operator has to use discretion with regard to the extent of removal of contused and dirty muscle in the course of the wound All foreign bodies should be removed if possible, particularly from the thigh and calf Search for a piece of clothing just distal to the portion of projectile should never be neglected Rough treatment of the tissues is to be avoided Haemostasis is important, and extravasated blood in buttock, calf, and thigh must be removed Time is undoubtedly wasted in a large muscular area in trying to extract many pieces of a projectile such as a hand grenade In such cases the larger wounds are dealt with alone

At this stage no counter-opening for drainage is made The wound is washed out—my own preference is for spirit if available —and then the smaller wounds are packed loosely with gauze wrung out in 1 in 1,000 solution of flavine In the larger injuries lint smeared with petroleum jelly is applied to the edges of the wound, Carrel's tubes are inserted, and gauze packing is placed at the orifice The details of this technique have been described in another paper, but stress may be laid on the correct method of placing the gauze at the orifices, and not between the deep parts of the wound and the tubes (Fig 2)—an all-important point

in treating the thigh The instillation of Dakin's solution soon becomes standardized in a hospital dealing with many wounded

Treatment when Fracture or Joint Lesion Exists

The preliminary treatment is that just described The incisions are made by preference on the anterior aspect of the thigh or leg, so that the irrigating fluid comes in contact with the bone If a counter-opening is made the fluid runs out and much of the objective of the Carrel method is lost. In the case of the femur it is important to make the incision of sufficient length to allow irrigation of every portion of the fracture and to pack the wound at the openings so that the muscular mass does not fall together This is aided by large rubber tubing three centimetres in diameter

A—Correct B—Incorrect

Fig 2—Showing introduction of Carrel's tubes into wounds of thigh. Gauze packs are placed correctly at opening of wounds in (A) whereas in (B) they are wrongly placed between Carrel's tubes and the wound surface.

The removal of bony fragments which are loose or nearly so is important. Small fragments should be extracted particularly when in muscle here in the presence of mild infection they cause suppuration, which spreads rapidly both in the thigh and in the calf Large fragments usually have some periosteal attachment. They should be left in the thigh and leg unless drainage is obstructed If articular cartilage is on a large piece the piece should be removed otherwise the joint will certainly become infected Rarely such a fragment acts as a foreign body Even if only one-third of the circumference of the bone is left new bone

muscle tissue should be ablated. Irrigation of these wounds is employed.

Before leaving the technique of operative treatment, the possibilities of secondary suture consequent on primary excision and sterilization by the Carrel Dakin method should be considered. During the war when conditions allowed, the extent of the infection was tested by the periodic estimation of 'organisms per field' When only one or two organisms were present per field on subsequent days, secondary suture with a few thick silkworm-gut sutures was employed. Naturally this was impossible at times of pressure and was generally interfered with by transportation of the patient.

Fig 1 is reproduced from the British Red Cross Society's *First Aid Manual* by kind permission of the publishers

FRACTURED FEMUR

In 1917 Martin and Petrie made some valuable observations with regard to infection of bones due to gunshot wounds Their conclusions can be briefly summarized as follows

1 From the surface of a divided or fractured bone exposed to infection bacteria may penetrate to deeper parts.

2 In an untreated fracture penetration is apparently unlimited.

3 If the dead bone on the surface of the fracture is removed early penetration is much reduced and may not occur at all

4 Penetration particularly of anaerobes, is greatly increased by reduction of the circulation through the injured bone

5 Penetration is increased by obstruction to drainage either of the bone or of the soft parts

6 The order of frequency and power of penetration of the bacteria found is (*a*) streptococcus, (*b*) staphylococcus, (*c*) anaerobes, (*d*) *B coli*

7 The rate of penetration is at its maximum during the first few days.

8. *Bruising*—an invariable accompaniment of projectile fracture—does not appear to facilitate penetration if the surface layer of debris is removed and drainage established.

9 In a septic fissure growth of bacteria is progressive and may

lead to infection of a distant part—for example, a joint Dissemination of infection throughout a bone takes place by penetration from the walls Little beyond the consideration of these findings in relation to thigh wounds will be necessary to understand why gunshot wounds of the thigh were a menace during the war.

Efficient drainage was invariably made difficult by the laceration of the muscles in addition. Many patients arrived at the operative centre in a condition of shock, owing to the extent of the wound or multiple wounds The employment of the Thomas splint as a first-aid measure in these cases is to be encouraged

The treatment of a gunshot wound of the thigh with fracture of the femur consists of: (1) The operative treatment of the wound and fracture, which has been described. Anti-shock treatment before operation will generally be necessary. (2) Reduction (3) Immobilization

Reduction and Immobilization

This is almost invariably realized when the "operation" is over, or at least it is facilitated. Often it consists in immobilizing the limb in the physiologically correct position; in any case, prolonged extension always gives the result desired. In post-war surgery it was not osteotomy for angulation that was necessary, but sequestrectomy for necrosed bone or grafting for non-union. Gradual reduction by weight extension is always desirable, and before discussing the technique it is not out of place to point out that any method of forcible reduction by stripping periosteum, the use of large bone-holding forceps, and internal fixation by chandlery-bolts screws, plates, etc, is likely to be followed by disastrous complications

British surgeons employed Thomas's splints, when possible, and a weight or fixed extension applied to the skin by adhesive strapping or a non-irritating glue. Laced boots and plaster gaiters had a trial. Transfixion nails and metallic loops—the latter passing between the tendo Achillis and tendons at the back of the ankle—were employed by the Italians and French. In fact, skeletal traction was first advised by an Italian physician

The British method produced reduction and caused no complication unless it was over traction in some cases but frequent soiling of the plaster was inevitable and constant renewals became necessary Apparatus around the ankle became more popular, and the footpiece glued to the foot, devised by Sinclair had many advantages. The glue ' consists of 50 parts ordinary glue 50 parts water 2 parts glycerin, 2 parts calcium chloride, and 1 part thymol. The mixture is sterilized It can be used for extension bands by applying gauze strips after painting the skin with glue or to fix a wooden footpiece to the skin. This is mentioned in some detail, for many surgeons doubt the advisability, and possibility of using Steinmann's pins or Kirschner's wires, which are familiar to all now in every case of gunshot wounds of thigh or leg That they would be used extensively there is little doubt, but with what success cannot be foretold.

Splintage

During the great war the standard splint for large flesh wounds of the thigh with or without fracture of the femur was the Thomas It is often convenient to bend the side irons at the level of the fracture or the knee In theory this does away with the exact method of extension but as a means of fixing the fracture and accessibility for dressing it has no superior Fixed extension will be used in transport and in some cases in hospital. Weight extension can be employed by one of the two recognized methods. Slings are probably better fixed by large safety pins than by the simple clip which is inclined to slip The latest clip is not likely to be available in large quantity In certain cases of multiple wounds the splint is used only as a supporting trough The Hodgen splint is still used by some surgeons.

In severe injuries the limb can be slung from an overbed beam, after the original method, described as the Balkan beam. In hospitals away from the line apparatus to sling the Thomas splint, such as beams with pulleys or Pearson's fracture bed is available. The latter can be used in a number of ways, with or without a mattress the limb can be extended without splinting, if necessary and the back of the limb can be dressed from below

FRACTURED LEG

Treatment for wounds of the leg is on the same lines as that of the femur Plaster of Paris is to be avoided during early treatment, but may be suitable in slight cases after a few weeks In the early stages the extent of swelling subsequent to the operative treatment cannot be gauged. It is likely that skeletal traction will be used by pin traction through the os calcis, particularly as it has met with such success in open fractures during the last twenty years Over-traction by too great a weight will lead to separation of the fragments, which is to be avoided The non-union of the tibia seen after the last war necessitated many bone grafts, and their number will be multiplied unless thought is given to this matter when skeletal traction is employed

The question of secondary suture of leg wounds does not apply as in open fractures due to road accidents Braun's frame is the ideal for these fractures rather than Thomas's splint *It is* in frequent use now, and everyone who may be called upon to do this work should become familiar with it

INJURIES OF THE FOOT

Conservative treatment should be employed as far as possible. Incisions on the sole of the foot may be necessary, but should be avoided Amputation of toes that are only adherent or are gangrenous may be required Those through the middle of the foot at the site of a wound are not likely to succeed, as infection spreads up the tendon sheaths For urgent surgery an amputation through the lower third of the leg is advocated for severe injuries of the foot This may be a useful stump, and if reamputation is necessary later the standard leg amputation with a five-inch to seven-inch leg stump is possible

INJURIES OF THE KNEE-JOINT

A punctured wound such as that due to a bullet or a small shell fragment, causing haemarthrosis only, is rare, but responds well to treatment There is a synovial wound only in this case More common and serious wounds are as follows:

1 *Small or Moderate sized Wounds with Fracture of the Knee involving the Joint with the Missile in situ*—These produce a dangerous condition owing to the presence in the joint of septic particles of clothing, earth etc and owing to the existence of fissures more or less prolonged into the shaft of femur or tibia whence arises a formidable osteomyelitis (Fig 3) Unless there is intervention death ensues in two-thirds of the cases from gas gangrene or articular septicaemia

2 *Fractures of the Bones forming the Knee-joint due to Penetration of a Condyle.*—These fractures are often followed by acute septic arthritis. If the patient is not carried off by acute septicaemia he is liable to suppurative arthritis to deep diffuse cellulitis of the thigh and to secondary haemorrhage from the popliteal vessels In short, if intervention is not practised at once amputation soon becomes necessary and only too often it is unable to save the patient s life This is exemplified by numerous specimens in the war collection

3 *Destruction of the Knee.*—Complete crushing of the joint is usually accompanied by fissures extending the length of the tibia and femur Often the vessels and nerves are damaged. Shock is considerable Gangrene quickly develops with the formation of gas and fetid sloughs if not true gas gangrene

Therapeutic Measures

In short, apart from the first type of injury wounds of the knee are of extreme gravity if they are left untreated in the first few hours. It is necessary to act at once, and to be beforehand in dealing with whatever may be happening The measures available are

1 Immobilization with or without aspiration. This is suitable for the first type. Repeated aspiration may be required.

2 More usually in the first type, primary excision of the wound or edges of skin, underlying tissues, and synovial membrane is made—the joint is washed out by some—and this joint lining is then sutured, but the overlying structures are left open. Immobilization is essential and subsequent aspiration may be employed.

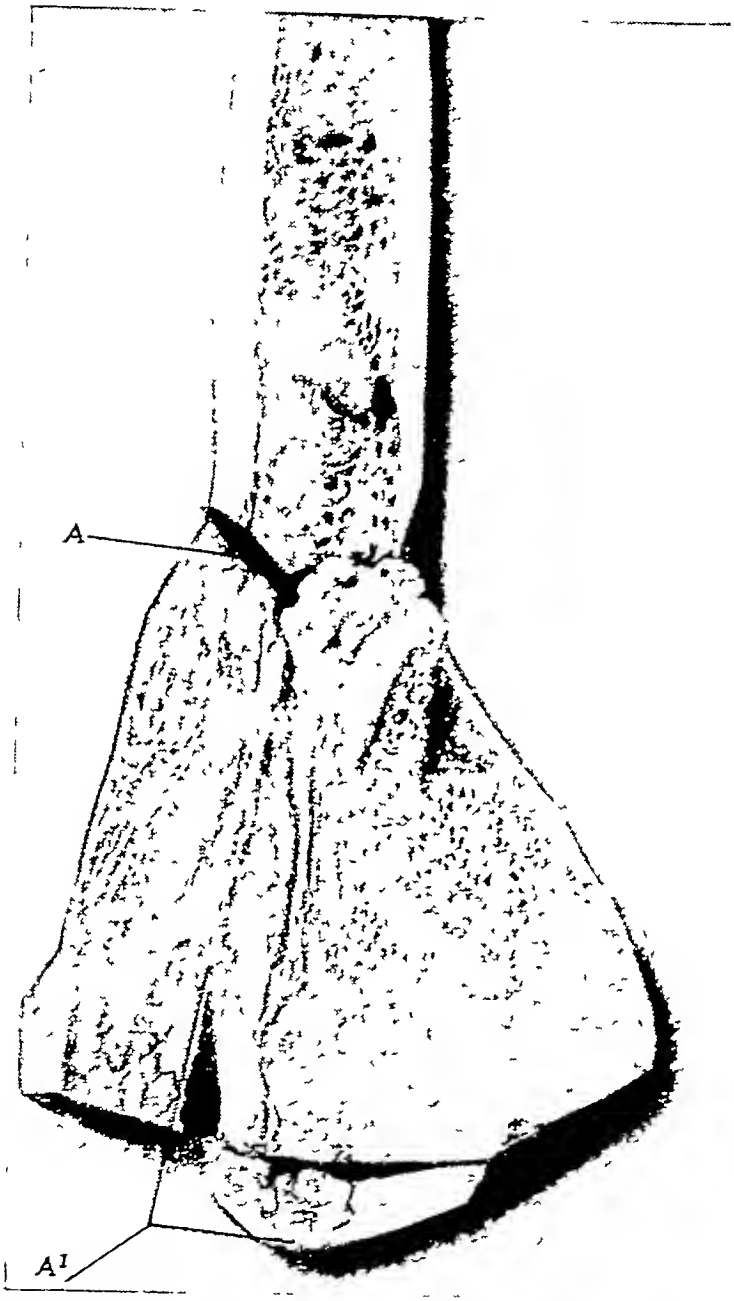

FIG 3.—Lower half of femur removed by amputation for streptococcal arthritis of knee seventeen days after injury. Longitudinal section of bone, with fissure opened out to show continuity of pus from fracture to articular cartilage. A, Fracture. A^1, Fissure extending to joint. Fig 3 is reproduced from the *British Journal of Surgery* (1917, 5, No 18), by kind permission of the editor and of the publishers

3 Arthrotomy with or without excision of the wound. This treatment differs in no way in its application or technique from that of civil practice.

4 Posterior drainage is unsatisfactory

5 Arthrotomy followed by active movement. This originated in Belgium in British hands it was not a success.

6 Primary excision of the knee is not practised by British surgeons for suppurative conditions.

7 Amputation is required in gross disorganization as a primary measure in suppurative arthritis before or during septicaemia, and in severe leg injuries extending into the knee-joint.

Primary amputation is indicated if the condyles and shaft of the femur are split up and there are fragments as high up as the middle of the bone because the risks of infection with so much loss of substance are considerable The prognosis of most of these amputations is always grave Pre-operative transfusion is valuable and the mortality is lower in the primary amputations than in those where delay has been incurred.

The conclusions are therefore (*a*) for articular bullet wounds employ simple immobilization with aspiration or primary excision (*b*) for foreign bodies in the joint arthrotomy and immediate extraction (*c*) for fractured patella, excision (*d*) for extensive injury especially with vascular injury amputation. After all operations on the knee the first dressing should be delayed and the temptation to insert a drainage tube be avoided No one with a wound of the knee (except the simple perforating bullet wound) ought to be evacuated without surgical exploration. If there has been an arthrotomy evacuation should be delayed until the twelfth day For the transfer the limb should be immobilized preferably in a posterior half-gutter plaster or an interrupted plaster It is better if the journey should be of less than twelve hours duration

Ankle-joint Wounds —These are often so extensive that amputation is indicated. When the fracture is limited to one bone treatment on the principles advocated may be carried out Excision of the astragalus when it is in pieces may help towards joint drainage

VESSELS AND NERVES

I have made little mention of injuries of these important structures, chiefly because others are dealing with them It is pertinent to point out that sciatic nerve sutures are often required in post-war surgery, but little vascular surgery is required at that date All wounds of muscle and bone complicated by vascular injury must be classed as grave if a large blood vessel is injured Secondary haemorrhage is seen far more frequently than in civil practice owing to suppuration In the thigh and calf (from the posterior tibial) it is serious, and often necessitates amputation Penetrating wounds of the gluteal region are liable to secondary haemorrhage This appears to be less common if the wound is opened up as a primary measure If it occurs when no operative measures have been undertaken and there is an entry and exit wound, the operator should have no hesitation in joining the two wounds Ligation of the internal iliac is to be avoided.

Amputations—These are also dealt with elsewhere, though I have frequently mentioned these operations Amputation of the middle or lower third of the thigh is required only too often, the operator will be in doubt as to the advisability of closing such wounds In primary operations six silkworm-gut sutures will often form an excellent closure and save pain in dressing As a secondary measure this is often unwise In preference to the guillotine operation, skin flaps may be cut and stitched back Carrel's tubes may be placed over the muscular mass for a few days, and then the skin flaps freed and allowed to drop over the end of the stump

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PRINCIPLES OF TREATMENT IN GUNSHOT WOUNDS OF JOINTS

By CLAUDE FRANKAU C.B.E. D.S.O., M.S., F.R.C.S.

If you consider the various joints in the body it will be clear that a joint comprising a single simple sac is uncommon. Most joints are complex and are divided more or less completely into compartments. This arrangement tends to limit infection from injury for a time and also makes efficient sterilization of the joint cavity by irrigation more difficult. The synovial membrane is much more resistant to infection than is usually thought: this resistance is due in part to the synovial exudate, which appears to be bactericidal, and partly to the nature of the epithelium lining the joint. Injury to the epithelium by the use of strong antiseptics, ether etc. is therefore to be avoided in the treatment of injuries. A secondary result of the changes in the character of the synovial exudate in infections is an alteration in the cartilage covering the bone ends forming the joint. The cartilage is partly nourished by the synovial fluid and if this is grossly affected the cartilage swells, softens and tends to flake away or become easily eroded if submitted to pressure.

FIRST MEASURES

The recognition of these points is of great importance in both treatment and prognosis of joint wounds. In the forward area a simple dressing should be applied and the joint should be immobilized by bandaging to the trunk or by splinting: nothing further should be attempted until the patient reaches the casualty clearing station. Here all cases should be regarded as urgent, and operation should be carried out as soon as possible. An *x* ray examination should be made to identify the presence of a retained missile and to estimate the degree of bone injury

Accurate localization of metallic fragments by stereoscopic or other means is of great value

The skin is sterilized over a wide area and the wound is excised down to the opening in the synovial membrane In most cases, if there is a retained foreign body, a wider opening of the joint is necessary or a separate incision may have to be made. If this is the case a fresh set of towels and instruments, etc , should be used After removal of the missile the joint is freely irrigated with saline or 1 in 2,000 flavine solution to remove fragments of clothing, etc , which may have been driven in, and to cleanse the joint cavity so far as is possible The joint cavity is then closed by suture of the synovial membrane and capsule of the joint in one layer with interrupted catgut stitches This may present difficulties in extensive wounds, but it is usually possible to mobilize the synovial membrane to some extent and so allow of suture of the opening, or fascial flaps may be employed to cover defects

The late Captain John Campbell suggested the use of the olecranon bursa to fill in a gap in the synovial membrane of the knee-joint, and, acting on his suggestion and with his help, I applied this method in three cases If it is impossible to close the synovial cavity, as may occur especially in the tarsal joints, the opening should be firmly packed with sterile gauze smeared with petroleum jelly , this acts as an effective seal and promotes local adhesions which close the joint Where the joint has been effectively closed the soft parts may either be sutured if the case has been treated early, or left for secondary suture if doubts are felt about the efficient sterilization of the surface wound , in this case a light pack of flavine gauze (1 in 2,000) is the best form of dressing After the application of dressings the joint is immobilized with extension on a suitable splint *immobilization with extension is of the greatest importance, and must never be omitted* Cases should be retained in the casualty clearing station for five to seven days if circumstances allow

TREATMENT AT THE BASE

At the base it will inevitably be found that in times of stress a number of patients will arrive with joint wounds which have

not been operated on in the forward area Some of these can be operated on in the way already indicated others in which frank infection is evident must be treated by methods to be described later

On arrival of a case that has been operated on the splint and extension must be adjusted or reapplied and the condition of the patient must be carefully reviewed Adverse symptoms are pain unrelieved by readjustment of the splint, pyrexia raised pulse rate, insomnia and loss of appetite. Adverse local signs are a dry and sloughy condition of the external wound marked effusion into the joint oedema of the limb below the joint and extreme pain on the slightest movement If these symptoms and signs are absent or abate with rest and adequate extension, movements may be allowed after the wound has been soundly healed for a week, provided there is no gross bony injury Movements should be active and not passive and must be very gentle at first Any reaction following movement is an indication that further rest is essential. Major Everidge's apparatus in the case of the knee-joint is of great value in assisting early immobilization of this joint. In an uncomplicated wound of the joint with no gross bony injury and healing kindly full restoration of function should be obtained in from six to nine weeks

If pain, pyrexia and effusion persist or arise after operation, aspiration of the joint must be performed at the most convenient spot. Gas-and-oxygen is preferable to local anaesthesia owing to the risk of infecting the area infiltrated with novocain. As much fluid as possible is withdrawn and retained for bacteriological examination. The naked-eye appearance of the exudate varies with the degree of infection (a) mild infections show a yellow fluid with flakes of lymph (b) in more severe infections the fluid is turbid (c) in advanced cases the fluid may be obviously purulent. A stained film of the exudate is of value if an immediate diagnosis is needed before cultures can be made Preponderance of mononuclear cells with few organisms which stain poorly suggests a mild or recovering infection. Excess of polymorphonuclear cells and large numbers of organisms are of grave significance Bacteriological examination may reveal any

type of organism gas-forming organisms, staphylococci, streptococci (non-haemolytic or haemolytic), etc , the most dangerous organism is the haemolytic streptococcus

If improvement follows aspiration it may be repeated at intervals of twenty-four to forty-eight hours , if no improvement results after forty-eight hours, or earlier in the case of the haemolytic streptococcus infections, more active treatment is necessary The joint must be opened freely and be gently irrigated with 1 in 2,000 flavine solution The wounds are subsequently left open, the joint being covered by a voluminous dressing and adequately splinted The introduction of drainage tubes into the joint is to be avoided, as they do more harm than good, and I am not in any way convinced that the Carrel-Dakin method of treatment is of any value in these cases Provided the general symptoms abate nothing further need be done , ankylosis is almost inevitable, and the limb must be kept in the optimum position for this

If pain and fever persist amputation is indicated, and must be carried out before the patient has gone too far downhill A special indication for amputation is spread of the sepsis outside the joint cavity into the surrounding muscles Excision as a means of eradicating sepsis in an infected joint is unsatisfactory in the larger joints owing to the shock of the operation In the smaller joints, such as the elbow, the free removal of bone fragments may assist drainage and conserve the limb, but no formal excision should be attempted

The following table gives the results in a small series of cases in which treatment by primary excision and suture of the wound was used

Wounds of Joints without Gross Bony Injury

	Cases	Healed	Failed
Knee-joint - -	16	14	2
Shoulder - -	4	4	0
Elbow - - -	18	16	2
Ankle - - -	7	5	2
Totals - -	45	39	6

AMPUTATIONS UNDER WAR CONDITIONS

By C MAX PAGE, D.S.O F.R.C.S

There was a time when amputations formed the major part of war surgery and they still represent a very important section of this work. In the pre-antiseptic period gross suppuration was the rule and the art of the limb-maker was but poorly developed. In consequence the experience and methods of the older surgeons have but little bearing on our practice to-day The intensive experiences during the great war and the subsequent study in this country of some fifty thousand amputés under the Ministry of Pensions authorities have provided us with evidence from which we were able to mould our current practice We have experimental evidence, both in regard to the technique of amputations and as to the value of stumps of various types. It may be admitted here however that the problems of the phantom limb and the development of painful nerve bulbs remain to be solved.

The indications for amputation cannot be considered in detail in this paper The decision will always rest on the judgment of the individual operator Some general observations, however on the factors which govern this important decision will not be out of place In the pre-antiseptic days any compound fracture of a limb due to a missile was regarded as an indication for prompt amputation. Under modern conditions this is by no means the case and primary amputations in the war were only carried out when there was gross injury not only to the bone but to the soft parts as well. In the case of missile wounds of the lower limb particularly those below the knee-joint level I cannot help thinking that our optimism in regard to conservative treatment carried us too far Anybody who worked in a pensions hospital for five or ten years following the war must have been

struck by the large number of compound fractures which required surgical treatment over a period of years The end-results may sometimes have been brilliant More often they left an indifferent limb, which remained liable to break down at intervals under stress The result in this class of cases should, in my opinion, be considered not only in relation to the wound treatment but to the general effect on the mentality of the patient Long hospitalization and repeated operations will disintegrate the initiative and enterprise of any but the most robust constitutions I believe that a primary amputation should be carried out in those cases in which, from a missile injury, comminution of the bone is such that prolonged bone infection and delayed union are likely to occur, especially in those instances where the damage is done in the lower half of the leg I do not think the same attitude towards compound fractures of the upper limb is justified In the lower limb a good stump in which suppuration has not occurred can be early fitted with a most satisfactory prosthesis In the arm nothing can replace satisfactorily the loss of the hand

GENERAL PRINCIPLES OF AMPUTATION

The principles which should guide us in carrying out an amputation will vary according to whether section is made through infected tissue or whether first-intention healing can be anticipated When dealing with the latter state of affairs the result obtained should be a final one, and great care should be taken so to carry out the primary operation that the stump may be durable and suited to the modern artificial limb I will now consider the general technique of amputation under the headings of flap formation, section of bone and nerves, and control of the major blood vessels

Flaps.—If the nutrition of the flap be the first consideration the simple circular flap is most satisfactory in this respect In general, therefore, flaps should be planned on this basis. There can be little doubt that long flaps tend to be unsatisfactory from the point of view of nutrition and innervation, although they may sometimes be employed with success Though the circular

flap in its exact form may be seldom used, it should remain the ideal of all flap design. In practice the circular flap will often be cut obliquely and vertical cuts may be made in it to make it more manageable when the bulk of the limb requires it. Such side cuts will convert a circular flap into antero-posterior or lateral ones of approximately equal size The total length of flap cut, whether circular or not, as measured on two opposed aspects of the limb should not exceed in length a diameter and a half of the limb at the level of section. Fascia and muscle should only be included in the base of a skin flap so far as is necessary to maintain its nutrition. In the final stump muscle and fascia, owing to their wasting and shrinkage are not present at its termination nor is their presence desirable The end of a stump which is to carry an artificial limb should be covered by skin and subcutaneous tissue that is just mobile on the healed bone. The termination of a stump should be tapered and not bulky The striking exception to the modified circular flap generally employed is particularly noticeable in the Syme amputation Some critical observations on this are made below

Bone Section —Bone should always be divided so as to give an even and more or less rounded-off end to the stump of the maximum diameter possible Projection of a bone of small diameter such as the fibula is a very undesirable feature in a stump Occasionally a good-sized artery is divided in the bone, and this can usually be occluded by crushing the bone on to it. Suture of muscle over the end of the bone is sometimes practicable. Alternatively a small amount of bone wax may be used I believe the employment of wax as a routine to be unnecessary In order as far as possible to avoid the formation of bone spurs the periosteum should be cleanly cut before the bone is sawn through and scraped away distally so as to expose the compact bone for section.

Nerve Section —There is no means by which the formation of some type of end bulb can be prevented. Pain in end bulbs most often occurs when suppuration has been present in a stump and when the cut ends of the nerve are so situated that they are

exposed to pressure. In larger nerve trunks the latter tendency can be avoided by cutting the nerve an inch or so above the line of section of the muscle I do not think severe traction of a nerve trunk or very high section is desirable It is generally accepted that the nerve should be divided clean across with a sharp knife after crushing. I do not favour ligaturing the nerve, except so far as this may be necessary to control bleeding In order to prevent post-operative pain the stump of the nerve may be injected with 90 per cent alcohol before closing the flaps Prevention of post-operative pain is most desirable in a sensitive patient its occurrence may well be the starting-point for the development of a painful and troublesome stump later

Control of Major Vessels.—The old authorities advocated the isolation of the main vein or artery before ligature There is not much to be said against the practice, but it is possible that in infected cases the local upset in the blood supply may favour secondary haemorrhage I can say, from a practical standpoint, that the ligature of the two vessels together gives satisfactory results.

AMPUTATIONS IN PRESENCE OF SEPSIS

If the amputation is through a septic field, or if there is active sepsis below the line of section to which the patient is showing little resistance, suppuration in the stump is to be anticipated In such circumstances it is most probable that the primary amputation will be followed by a later final one. In this case the primary amputation will be designed so as to minimize the risk of spreading infection and to leave enough tissue for a satisfactory stump to be formed at the secondary amputation.

At one period during the war the simple guillotine operation was advocated. In the case of a virulent spreading gas infection this may well be sound practice In my opinion, however, in its crude form it is seldom necessary. The guillotine stump is a depressing one to the patient . it is painful for dressing, and is more liable to secondary haemorrhage than the more protected type In these circumstances I advocate the use of a short

circular flap the length of about half the diameter of the limb and cut slightly obliquely so that one flap overhangs the bone end. Few if any sutures should be employed, and the cavity is packed with paraffin gauze. This pack should be left *in situ* for four or five days or longer if the general condition is satisfactory

Drainage—It is customary to drain amputation wounds whether carried out under clean or septic conditions. When sepsis is not present the drainage is merely to prevent the development of a haematoma and for this purpose a rubber dam may be left in for twenty four or forty-eight hours. Some surgeons prefer to dispense with drainage altogether in clean stumps but it is certainly difficult to control oozing by pressure in the loose wound at the end of an amputation stump

REGIONAL AMPUTATIONS LOWER EXTREMITY

The ideal types of final amputation may now be discussed By final amputation is meant one carried out as a primary measure when healing by first intention is anticipated or when a second reamputation is carried out after the infective process has been controlled In these circumstances a durable stump suited to the standard artificial limb should be the aim In the lower extremity where prosthesis is of the greatest importance the most satisfactory amputations giving good functional results are (1) the Syme amputation (2) below knee seat of election (3) above-knee seat of election (4) amputation at the hip-joint. Amputation at other levels for one reason or another may be carried out, but none of them gives full functional value and some I think should be definitely condemned as either crippling or unlikely to stand long wear Into this group fall the Chopart and Lisfranc amputations and below knee amputations with more than seven inches of tibia If the views and methods of the English limb-maker be considered, any thigh amputation longer than ten inches must also be condemned. It is true that in America and Germany the Stokes-Gritti amputation is still considered to give a useful stump English experience however is not in its favour

The Syme Amputation

The value of this amputation has been the subject of a good deal of controversy, and I will limit my remarks on it so far as possible to observed facts If completed cleanly and neatly with a firm well-fitting heel flap it gives excellent service in children It provides a true end-bearing stump, which is very convenient at this level It will carry an effective if not elegant prosthesis If the bone section is carried out at the classical level (a quarter to half an inch above the ankle-joint) it does not allow of the fitting of an artificial limb with a symmetrical ankle This objection is important to women from a cosmetic standpoint, and is partly overcome if the amputation is modified by using a small heel flap and cutting the bone one inch above the ankle-joint level

In men the average results of this amputation during the war were unsatisfactory. The Ministry of Pensions circulated in 1934 an analysis of fifty-four Syme amputations It was found that thirty-eight of these cases had undergone reamputation between 1920 and 1933 In a group of twenty-two cases, investigated in relation to their durability, it was noted that only six took full end-bearing for ten years or more The average period during which end-bearing could be tolerated was seven and a half years

This failure of the Syme carried out under war conditions was put down in about 25 per cent of the cases to the presence of sepsis at the time of operation Displacement of a bulky end flap was another cause of trouble The development of callosities and ulceration, especially in relation to the anterior scar, was often noticed Painful nerve bulbs are as common and as troublesome in this amputation as in stumps at other levels Nutritive disturbance from a poor circulation was often met with. The above complications are sometimes overcome without reamputation by fitting an artificial limb bearing on the tibia or even the tuber ischii.

I advocate the Syme in children, and it may be worth while in young men and women provided there is no sepsis It should

be noted that in children this amputation involves the removal of the lower epiphyses of tibia and fibula and so affects subsequent growth of the stump At operation great care should be taken to maintain full nutrition of the heel flap that flap should be shorter than the classical form and the bone section should be made about an inch above the ankle As many nerves as can be recognized should be cut short in the flaps In the presence of sepsis and in the elderly the amputation is to be condemned It is very unsatisfactory when oblique weight-bearing is imposed by the presence of a bow leg

Below-knee Seat of Election

This amputation can now be clearly defined. Ideally the bone section should leave six inches of tibia in the average adult and seven inches in a tall person. The measurement is taken from the upper border of the tibia at knee-level Longer stumps give no increase in functional value and are liable to nutritional trouble. The shortest below knee stump of functional value is about three inches. If less tibia than this must be left an above-knee amputation should be performed The design of the flaps for this amputation may often be governed by the conditions for which it is carried out. They should always be planned with the idea of maintaining so far as possible good blood supply and a normal innervation.

Above-knee Seat of Election

It is customary to measure this stump from the crutch or pubic bone The ideal length is nine inches for short and ten inches for tall patients. Greater length than this has no functional value and impedes the fitting of the best type of modern symmetrical limb The shortest length of an above-knee amputation that is of functional value in controlling an artificial limb is about three inches Less bone than this, however should be left as some bone in the stump facilitates the fitting of a tilting table type of prosthesis. Modified circular flaps amounting to approximately equal length antero-posterior flaps give a satisfactory result and are generally practicable.

Amputation at the Hip-joint

This amputation is seldom carried out, and it is only necessary to advise that it should be planned to leave a convex and not a concave surface for the fitting of a limb To this end, unless there is some contraindication, the head of the femur should be left in the acetabulum, the neck of the femur being sawn through

AFTER-TREATMENT OF LEG AMPUTATIONS

After above- and below-knee amputations flexion at hip or knee should be avoided The development of fixed flexion at either of these joints prevents limb-fitting till deformity has been corrected The prevention of habitual flexion is particularly necessary in septic cases, where treatment in recumbency is prolonged The thigh or leg stump should lie straight while the patient is confined to bed, and when healing has progressed far enough exercise of the stump should be carried out. As soon as the wound is soundly healed the stump should be prepared for the fitting of an artificial limb In the thigh a temporary pylon applied a month or so after amputation is a useful measure to this end In the leg this method is not so easily applied Active exercise, massage, and elastic pressure applied to the stump will, however, reduce the oedema and render the stump ready for the fitting of the final artificial limb in a month or so.

REGIONAL AMPUTATIONS UPPER LIMB

In the upper limb the prehensile value of the hand is irreplaceable by any prosthesis hitherto invented In consequence a conservative attitude in regard to amputations in either the hand or the arm should always be adopted When amputation is decided on the determination of the ideal level for section is not so rigid as in the lower extremity I will, however, give such details as to useful levels for division of the bone as meet with general acceptance

Forearm —Disarticulation at the wrist-joint or bone section immediately above it gives an unsatisfactory stump, difficult to fit with a prosthesis The ideal is to retain six to seven inches of

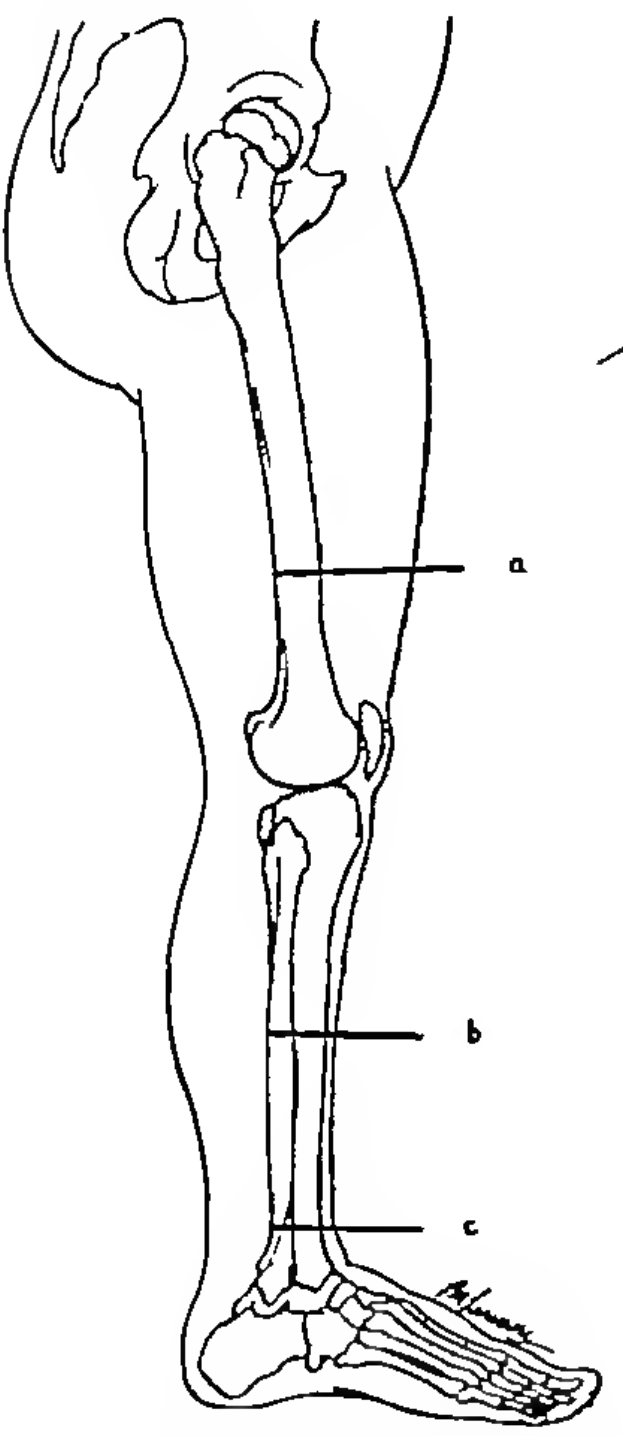

FIG 4.

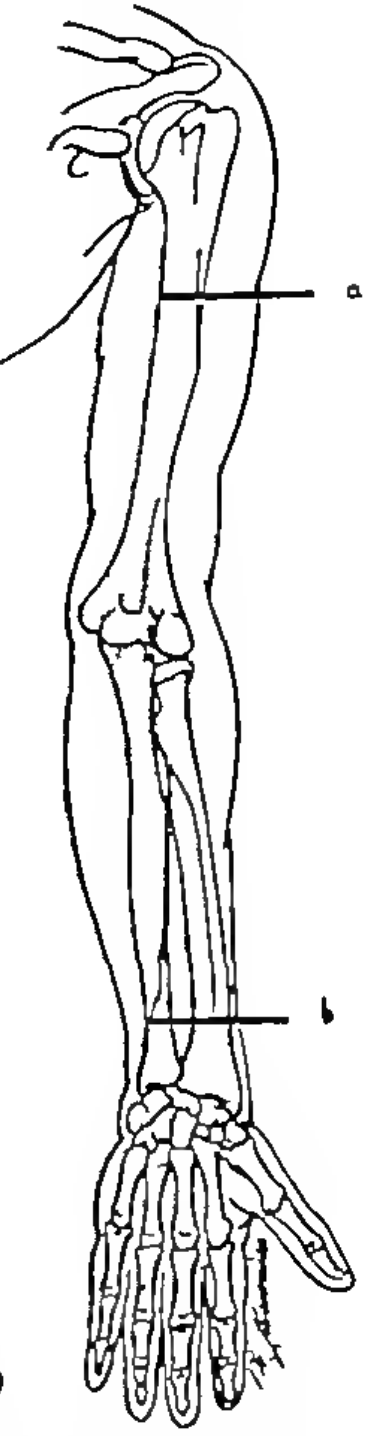

FIG 5

FIG 4.—Diagram indicating satisfactory levels for bone section in amputation of lower extremity. Section of bone in the shaded areas leads to unsatisfactory stumps. *a* = Ideal level for above-knee amputations—9″ to 10″ of femur measured from the crutch. *b* = Ideal level for below knee amputations—5 to 7″ of tibia. *c* = Level of bone section for a modified Syme—the most useful amputation about this level.

FIG 5.—Diagram showing useful levels of bone section in upper extremity amputations. Section of bone in the shaded areas leaves unsatisfactory stumps. *a* = Section above this level leaves a stump to which an artificial limb cannot be fitted. *b* = Most useful level for forearm amputations.

the radius and ulna The minimum length of these bones which allows a good-fitting and useful substitute is from two to three inches If two inches of forearm bone cannot be left the patient will be better off with a supracondylar amputation The flaps for amputations in this area may conveniently be approximately circular. The central scar overlying the bone, if mobile, is satisfactory in the upper extremity The ingeniously devised so-called kineplastic stumps have proved a failure Their intention was to use the forearm muscles independently to act on an artificial hand

Upper Arm —Disarticulation at the elbow, like similar operations at the wrist and knee, does not give a useful stump The best upper-arm stump is one in which the humerus is divided some two inches above the epicondyles Any length of humerus, however, less than this should be left, if only for cosmetic purposes , anything less than four inches of humerus measured from the tip of the acromion cannot be fitted with a useful artificial limb. Even circular flaps are ideal for upper-arm amputations, a central scar being most satisfactory.

CONCLUSION

It may appear that the directions for lower extremity amputations are somewhat dogmatic But I would emphasize that they are based on the opinions of most of those surgeons and limb-makers who have had under observation the large amount of material provided by the war

I would like to acknowledge my indebtedness to the medical staff of the Pensions Ministry for some statistical information, especially in relation to the Syme amputation I should also like to thank Mr. Desoutter for valuable advice on the best levels for lower extremity amputations in relation to the fitting of artificial limbs

WOUNDS OF PERIPHERAL NERVES AND BLOOD VESSELS

By PHILIP H MITCHINER C.B.E M.D, M.S F.R.C.S

In war surgery it must be realized that when injury affects either the blood vessels or the peripheral nerves the wound of the surrounding tissues which will undoubtedly accompany the injury must be taken into consideration. The severity of this wound will in many cases render unnecessary any doubt as to either the diagnosis of the extent of the injury to or the treatment of any individual nerves and vessels. It cannot be emphasized too strongly that prompt and thorough excision of the wound track must be in all cases carried out In doing this the condition of any damaged nerves and vessels may be ascertained and such lesions as are present may be dealt with

In wounds of peripheral nerves suture should be carried out in all cases provided this can be done without tension on the divided ends the limb must then be splinted so as to support paralysed muscles in a position of relaxation

Where blood vessels are injured they should as a general rule, be completely divided and ligatured above and below Attempts made to reconstruct the lumen are dangerous and are likely to result in severe secondary haemorrhage should the wound become infected moreover the ultimate results of such a procedure are unsatisfactory

INJURIES TO NERVES

Wounds and injuries to the peripheral nerves are commonly met with in war surgery and, as excision of the wound is required in all cases, failure to recognize the lesion should not occur as the divided nerve ends will then be apparent but examination of the limb should not be neglected because excision has to be

performed and it is helpful to the surgeon to know what damage he is likely to encounter. The limb should therefore be examined for any evidence of muscle paralysis or anaesthesia The following lesions of nerves may be found complicating a wound: (1) contusion; (2) division; (3) partial ablation, where a greater or less extent of the nerve trunk is destroyed and missing

CONTUSION OF NERVE

In these cases the nerve looks slightly swollen, with its sheath reddened or actually infiltrated with blood. There is no obvious loss of continuity of the nerve fibres, though in most cases loss of conductivity can be demonstrated clinically.

Treatment.—In cases of contusion with no loss of continuity no surgery should be attempted on the nerve trunk, as recovery is the rule, but in the meanwhile the limb should be so splinted that paralysed muscles will be in a relaxed position; if these react to faradism that form of electrical treatment should be employed to stimulate them daily until voluntary contraction reappears. In severe cases in which no faradic response can be obtained galvanic stimulation must be carried out daily until a faradic reaction can be elicited.

DIVISION OF NERVE

The trunk of the nerve may be cut clean through as if divided by a knife, but more commonly the ends are ragged and bruised, occasionally the nerve may be only partly divided, often with a portion of metal embedded at the point of injury. In these wound cases, owing to the pulping and damage of the surrounding muscles, the nerve ends are not separated to any great extent and are easy to identify, pick up, and approximate Anaesthesia of the skin and paralysis of muscles in the area supplied by the nerve below the point of section will of course be present, though they are often confused by the extent and results of the accompanying wound.

Treatment.—In every case the nerve ends must be carefully pared with a very sharp knife till the trunk is clean and unbruised. The nerve sheaths of the peripheral and distal ends

should be gently freed by dissection from the surrounding tissues (all damaged muscles having been excised) and approximated by a series of catgut sutures passed through the perineurium, always provided this can be carried out without any undue tension being exerted on and without rotation of the nerve ends When the suture is securely accomplished the nerve at the point of operation should be embedded if possible in healthy muscle but if this is not feasible it should be enwrapped in fascia or fat to prevent adhesions When completely excised the wound should be closed with drainage if necessary and the limb splinted so as to rest the wound and relax any paralysed muscles In many cases it will be found that infection has already occurred in these wounds before they are seen by a surgeon in this eventuality it is a common practice to leave the nerve ends unsutured until such time as the infection has cleared up when they are united by a subsequent operation on the lines already indicated. My own practice however is to suture these nerves in the presence of moderate infection and I can report good results in the majority of cases with the saving of much time in recovery

PARTIAL ABLATION OF NERVE

This is a common condition seen in most lacerated wounds, and is important not only because the ends of the nerve are widely separated but also because the surgeon may overlook the nerve ends unless careful search is made for them when the wound is excised.

Treatment—In cases where a gap of several inches is left between the nerve ends it is useless to attempt to carry out any form of primary suture all that it is advisable to do in addition to excising the wound, is to clean the cut ends of the nerve and if possible pull down and ligature the perineurium over the divided nerve filaments so as to prevent the formation of a large neuroma and its adhesion to surrounding structures. Subsequently the distal end of the nerve may be implanted laterally into a neighbouring nerve trunk if one exists, or suitable means, such as tendon transplantation or arthrodesis, undertaken to ensure a useful limb

PROGNOSIS OF NERVE INJURIES

It must be realized that further treatment will be necessary for many months in all cases of nerve injury This treatment consists in the daily application of the galvanic current and massage to paralysed muscles until such time as they react to faradism, which may then be employed At the same time it is very necessary to protect the limb from external trauma and, in cases of injuries in the upper extremity, to warn the patient of the danger of holding lighted cigarettes or matches between partially insensitive fingers

With all nerves the nearer the body they are divided the longer will be the period before recovery is complete, thus when a sciatic nerve is divided in the upper part of the thigh an interval of from two and a half to three years is to be expected before recovery takes place In the case of a similar wound in the upper limb this period is usually a year or eighteen months, but may be slightly longer

The prognosis is always best after primary suture where no sepsis has intervened. It is never so satisfactory in the case of delayed suture or sepsis, and no really good results are to be expected after nerve grafting or implantation. The end-results are much better with some nerves than with others An almost perfect end-result may be anticipated with the sciatic and musculo-spiral (radial) nerves where primary suture has been successful, but with the median and ulnar nerves muscle weakness and sensory disturbances persist in nearly all cases

INJURIES TO BLOOD VESSELS

Injuries to blood vessels are extremely common, and, of course, occur in every wound seen, but it is particularly with injuries to the larger vessels of the limbs that we are concerned In respect to damaged small vessels, which will be encountered in all kinds of wounds, it cannot be emphasized too strongly that in excising any wound it is necessary to remove tissue until spurting vessels are met with in place of the ooze first seen on a wound surface and, moreover, it should be remembered that the *per primam*

healing aimed at by excision is possible only if adequate haemostasis is secured before the wound is closed.

As to damage to the large vessels, it is evident that the cutting off of the blood supply to a wounded limb will not only increase the risk of its death but will also greatly favour the occurrence of infection, and especially those forms due to anaerobic organisms (gas gangrene and tetanus) It is therefore justifiable in many cases where damage has been done to the main vessels of the limb especially if accompanied by gross muscle-crushing or fracture of the bones, to perform immediate amputation with the object of saving the patient's life

As with nerve lesions so also in the case of blood vessels we meet with (1) contusion (2) division (3) partial ablation It must be remembered that Nature by a general fall in blood pressure, the coagulability of the blood (especially in the presence of damaged muscle tissue) and the torsion of the vessel wall which occurs in all severe wounds, does much to arrest haemorrhage, and is often successful even where main vessels are torn across. It is not however, safe for the doctor to rely on this natural arrest of haemorrhage as the rise in blood pressure consequent on treatment and the occurrence of infection of these wounds are sufficient to loosen the clot and cause severe reactionary and secondary haemorrhages.

First Aid

In such cases the first-aid treatment is of great importance in saving the patient's life All personnel engaged on first aid duty must be taught to look for haemorrhage cases first and to give immediate treatment A pad, improvised or otherwise is pressed into the wound and held firmly until a dressing and bandage can be applied If an artery is bleeding pressure is applied to the appropriate pressure point until the dressing is in place. All wounds of the lower limbs are to be treated as stretcher cases. The tourniquet is not to be used indiscriminately but only when it is certain that a large artery is bleeding or when a limb has been torn off, when *it must be applied as close above the wound as possible.* A simple type must be chosen,

and one that can be efficiently and rapidly applied even in the dark.

The Tourniquet

Many kinds of tourniquet exist, but probably the improvised types are the most useful. Careful judgment is required in their use, unless a large artery is obviously injured the tourniquet should be applied only after the simpler forms of treatment have failed The tourniquet should always be put on as far down the limb as possible—that is, near the wound—so that the blood supply of uninjured parts is not interfered with The rule of relaxing the tourniquet after fifteen minutes should be observed, but it should be left *in situ*, with an orderly ready to tighten it up again if necessary. When a tourniquet has been applied a note must be made of this fact, together with the time of application, on the casualty card. should this not be available the fact of application must be recorded on the patient's forehead It should be noted that where a tourniquet has been applied and it is subsequently decided that immediate amputation is to be carried out this should be performed without removal of the tourniquet, and immediately above it; this procedure saves the patient very considerable shock

Clinical Indications

Though haemorrhage is visible to the naked eye it may sometimes be difficult in the case of a penetrating wound to be sure whether deep vessels are damaged or not In this respect examination of the distal pulse, the possible presence of a pulsating swelling, or deep tension in the limb should be looked for In other words, with a small penetrating wound internal haemorrhage occurs in a limb just as in the coelomic cavities, and will present the same general signs, though to a lesser extent As a rule the presence of a persistent tachycardia is an indication that there is vascular damage, usually with arteriovenous communication, unless the patient is developing or has developed gas gangrene, which is the other common cause of continued rapidity in the pulse rate in patients recovering from the effects of wounds.

Treatment

Subsequent treatment should aim at ligature of the damaged vessels and as Makins pointed out in 1917 simultaneous ligature of the artery and vein leads to retention of more blood in the limb and further improves the conditions necessary for the preservation of its vitality The surgeon will soon become acquainted with the main arterial trunks, and in the early stages of his career may attempt to carry out operations for the repair of vessel walls and the re-establishment of circulation. This line of treatment is not justified in the majority of cases, as it means submitting the patient to a lengthy operation, the results of which are usually to produce thrombosis at the suture line with obliteration of the vessels and where the circulation is maintained subsequent examination after several months has shown that the majority of these patients develop arterial or arterio-venous aneurysms

Following ligation of the vessels the limb should be elevated and, if necessary splinted to secure rest, while the patient is to be encouraged to contract the muscles gently and massage may be given to aid the circulation. I must repeat that a sharp eye should be kept for gangrene, which is more likely to occur in the lower limb being very rarely seen in the upper even after ligation of the axillary vessels Infection also must be watched for As already stated, it will be ill resisted in the devitalized tissues, so that its appearance is of serious significance and calls for immediate and drastic surgical treatment In cases in which gas gangrene manifests itself prompt amputation will offer the best chance of saving the patient's life.

TRAUMATIC AND ARTERIOVENOUS ANEURYSMS

One of the results of failure to recognize damage to blood vessels in a wound is the subsequent and usually gradual appearance of some sort of traumatic aneurysm. It is not in large wounds that vessel damage is likely to escape notice, but in small penetrating wounds where the exit and entry of the missile are situated at some distance from the lines of the blood vessels.

These small wounds frequently heal without complications, but the patient gradually notices a feeling of fullness and tiredness developing in the limb, especially after use, while in some cases a definite bruit may be detected by him and pulsation be present in the veins distal to the wound In the early stages the surgeon should be led to suspect the development of such a vascular lesion by the presence of a persistent tachycardia in a patient in whom no obvious cause for this can be demonstrated. As will be seen from the above description, the onset of these aneurysms is usually gradual, and it is several weeks before they are clinically obvious. There are occasions, however, when, just as the wall of an artery may give way and cause secondary haemorrhage, so an arteriovenous communication may manifest itself suddenly. In this case the patient shows all the signs of collapse and internal haemorrhage, while the affected limb will be found distended, with tortuous pulsating veins

TRAUMATIC ANEURYSMS

Following an undetected wound in an artery the resultant traumatic aneurysm enlarges gradually in the surrounding tissues, the pressure of which limits the extent of the sac In superficial vessels such a lesion presents itself as a rounded swelling with expansile pulsation in the course of the vessels, while in deeper tissues a sense of fullness and discomfort is all that is usually manifest. Pressure on the artery above the aneurysmal sac of course obliterates the pulse in this There may be pain and oedema distal to the aneurysm from pressure on surrounding nerves and veins

Treatment consists in exposing the sac, ligaturing the main trunk both above and below it, and, where practicable, excising the sac itself, though this is not essential and should not be carried out if it involves any risk of damage to important structures in the sac wall.

ARTERIOVENOUS ANEURYSMS

These occur where a wound involves contiguous vessels such as in the subclavian and axillary regions in the upper limb, the

thigh and popliteal regions in the lower limb, and the carotid region in the neck. As already stated, these communications develop gradually in most cases, though rarely they may have a sudden and dramatic onset it is usually not until at least six weeks or more after the wound that the condition can be diagnosed with certainty though a persistently rapid pulse in any patient should lead to the suspicion of a developing arteriovenous communication. As a rule the patient is aware both of discomfort and pain and of a bruit in the affected limb This bruit may often be heard when near the patient and can always be detected on palpation and on auscultation, while the superficial veins below the lesion may generally be seen to be tortuous distended, and pulsating It must not be forgotten that such a communication may complicate a fractured skull and occur in the cavernous sinus, between the internal carotid and that blood space, giving rise to distressful cerebral symptoms and a pulsating exophthalmos.

Treatment

From the point of view of treatment it makes little difference whether an aneurysmal varix or a varicose aneurysm is present for as already enunciated ligation of both the artery and the vein above and below the communication offers the best opportunity of cure Unless the patient is seriously inconvenienced by the communication it is wise to defer this ligature of the vessels for at least three months from the time of the wound in order that a collateral circulation may be well established. The operative treatment, however should not be delayed unduly since this increases the involvement of surrounding structures and makes operation far more difficult.

Only very rarely is it justifiable to attempt repair of the vessel wall at the point of communication but where operation has to be undertaken very early and especially in the lower limb, where doubt may exist as to the efficiency of collateral circulation such repair may be carried out at times. Even should an aneurysm subsequently occur the initial procedure will have permitted the patient's collateral circulation to develop in the

meanwhile As stated elsewhere, such repair operations are disappointing in their results, in that in many cases immediate thrombosis arises at the site of operation, and in the vast majority of the remainder the giving way of the scar results in the subsequent formation of an aneurysm

CONCLUSION

As will be gathered from the foregoing remarks, injuries of the peripheral blood vessels and nerves are in themselves often unimportant compared with the grave damage that is likely to be caused by aerial bombs Experience has shown that the most severe wounds may be expected, and these will quite overshadow any vascular and nerve lesions On the other hand, it is important to recognize and treat these conditions in minor wounds in the case of injuries of the blood vessels the recognition of damage to the main vessels of a severely wounded limb may often cause the surgeon to determine upon immediate amputation—a step which will save the patient a long and painful convalescence with the chance of a useless and painful limb, and will often be life-saving in its effects—while in the case of a slight wound the recognition and prompt treatment of vessel involvement will avoid the inconvenience and danger of a traumatic or arteriovenous aneurysm

ABDOMINAL INJURIES OF WARFARE

By GORDON GORDON TAYLOR O B.E M.A , F R C.S

Ever since 'the dark backward and abysm of Time' the belly of an enemy has constituted an instinctive target, and the relative proximity of adversaries has in no small measure determined the incidence of abdominal wounds received in conflict The vulnerability of the abdomen in the geological era when but a short space can have separated rival foemen is attested in museums, where may be seen portions of the human lumbar spine with impaled flint arrow heads, some of these relics embedded in the anterior portion of the vertebral bodies limn with unerring surety the transabdominal course of a missile shot long ages ago by some enemy hand of the Neolithic period, a dual monument to victor and to slain.

INCIDENCE AND MORTALITY

In the last great European conflagration with the augmented frequency of wounds produced by artillery fire injuries of the abdomen amounted to only 2 or 3 per cent of all the wounded who reached an organized surgical formation, but of course large numbers of those injured in the abdomen died on the field It is of interest to learn that abdominal wounds accounted for no less than 9 per cent of the casualties sustained in the recent air bombardments of Barcelona, and were mostly of a penetrating character Many of those injured in the abdomen by enemy aircraft especially by means of the so-called liquid air bomb had multiple wounds The wound of entry may be small and easily overlooked and yet most grievous damage may have been inflicted on the abdominal viscera. Careful scrutiny must be made of the whole body in the case of men and women injured by this form of enemy action.

Wounds of the abdomen which are inflicted by the modern missiles of warfare exert their lethal effect by producing haemorrhage or by engendering sepsis either through infection carried in with the fragment of high explosive or through damage to the hollow viscera of the belly, especially the gastro-intestinal tract The bowel is that portion of the alimentary tube most liable to be wounded, and is damaged nine or ten times as often as is the stomach

Personal experience and the published figures of other military surgeons testify that haemorrhage or the shock-haemorrhage syndrome is largely responsible for the deaths occurring in the early hours after wounding, and that those who die later mainly perish from sepsis This does not absolve the surgeon from the necessity for rapidly deciding whether to operate or to abstain, even in those cases of penetrating wound of the belly where haemorrhage is not the prominent clinical feature

The dangers attaching to wounds of the hollow abdominal viscera preponderantly outweigh those attending lesions of the solid organs, unless associated damage to important and intimately related blood vessels threatens life in all abdominal injuries early diagnosis and decision are the necessary prelude to success It must, however, be admitted that hollow viscera have escaped injury when the intestinal area has been transfixed by missile or even by bayonet, and Gordon Bell's famous case furnished indisputable evidence that a natural cure might result when the bowel was actually penetrated Spontaneous healing of gastric wounds has also been recorded Such results are the freaks of fortune, and are to be disregarded in the formulation of rules for those called upon to deal with gunshot wounds of the belly. In the abdomen there are no insignificant wounds

DIAGNOSIS AND PROGNOSIS

The diagnosis of intestinal injury due to a penetrating wound in the abdomen is never beset with the same difficulty that obtains in deciding whether the bowel has been damaged by contusion or non-penetrating violence, and the indications for treatment are crystal-clear Whatever the traumatic agency—

a laceration by spike or stake, a stab with a knife, dirk or dagger, a bayonet thrust, or the more frequent gunshot wound from bullet, shell, or bomb—the general principles of treatment are alike. A penetrating wound in the abdomen probably means a penetrating wound of bowel or other abdominal viscus, and demands the earliest surgical intervention unless a wisdom and prescience born of great experience justifies self restraint

An escape of faecal material or flatus from a wound involving the abdominal parietes or even a portion of the body somewhat remote from the peritoneum is self-evident proof of an intestinal lesion, an abundant and persistent discharge of blood from wounds in the back, flank, or anterior belly wall, an ebb which flows the faster and with greater force when the patient coughs or makes any effort, will likewise suggest some deep visceral lesion, and will call for surgical exploration No comment is needed upon those cases where a portion of bowel or omentum projects from a wound in this region and still more significant will be the diagnosis, and still more urgent the need for resuscitatory methods and preparation for laparotomy if the wounded man is shocked blanched, or passes blood from the rectum or if there is haematemesis. The situation of the wound may however not at first suggest an involvement of the coelomic cavity or its contents it is perhaps hardly necessary to reiterate the frequency with which gunshot wounds of the buttock implicated the peritoneum or to emphasize the danger with which these injuries were fraught in the war of 1914–18

The wound of entry may be in the thorax, and the missile, passing through the diaphragm, may implicate the gastro-intestinal tract. It has been pointed out by others, as well as by me, that the immediate prognosis of abdomino-thoracic wounds is in very many cases largely determined by the nature of the abdominal injury and that those accompanied by a wound of a hollow viscus are very fatal Sir Cuthbert Wallace found that only seven out of twenty-eight such cases in his collective series were evacuated to the base Gask and Wilkinson saved only three out of thirteen such cases. Others were more fortunate for A. L. Lockwood of Toronto had eight successful cases out of

twenty, and I have a record of eleven recoveries out of twenty-two abdomino-thoracic wounds associated with hollow viscus injury, of which several were complicated intestinal lesions The wounds of entry may be even more remote from the abdomen, they have been encountered in the supraclavicular fossa or as far down the lower limb as the region of the patella It may be pointed out here that these longitudinal wounds are very fatal in character

The bowel may also be damaged by small bony spicules being driven through the peritoneum, although the projectile itself does not jeopardize life, the intestine being ruptured by indirect violence without any penetration of the coelomic cavity by the missile. This type of case was familiar to all such officers as had first-hand experience of gunshot wounds of the abdomen in the 1914–18 war, the small bowel in these "burst wounds" gives way either into the mesentery or along the anti-mesenteric border, the large bowel bursts more frequently between the taeniae coli, and often behind the peritoneum, occasioning a fatal retroperitoneal cellulitis or diffuse peritonitis, as was shown by the late Hamilton Drummond and by Sir John Fraser It must be remembered that the mere fact of penetration apart from the presence of any intestinal or visceral lesion is in itself a serious menace to life, since infection of the abdominal cavity may occur from the wound of entry and a fatal peritonitis may ensue

What symptoms and signs enable us to make a diagnosis of intestinal injury in the less obvious cases of gunshot wounds of the abdomen? Rigidity, pain and tenderness, vomiting, the facial expression, and a rising pulse are all suggestive No one sign or symptom is diagnostic, but when they are present in combination the clinical picture becomes more clear An *x*-ray examination will give valuable information as to the direction of a wound produced by gunshot injury and may furnish useful information as to the best mode of approach in the particular case

Many of the foregoing paragraphs have only an academic value, the implications of a wound of the abdomen are obvious

Every wound whether penetrating or not should be thoroughly explored excised and disinfected Even if an occasional operation should prove to have been unnecessary the patient will suffer little or no detriment from the exploration, nay rather, with the excision of his parietal wound convalescence will be more safe the wound should heal more kindly, and the surgeon will feel secure

Shock

The treatment of shock has already been dealt with by the very surgeon who did so much to clarify our ideas of wound shock in the front line areas during the great war (E M Cowell) and it must suffice to reiterate that every effort must be made to combat the development of secondary shock As regards the intravenous administration of fluids in those with severe shock, I was never convinced of the utility of saline or bicarbonate of sodium solutions in warfare while the employment of gum acacia solution must have cost many lives Fortunately the recent work of Stuttiford of New York has severely discredited this preparation and it has now doubtless received its *coup de grâce*. The greater the share played by loss of blood in the shock haemorrhage syndrome the more valuable is blood transfusion and in all severe cases its use is demanded as a primary measure In cases of pure shock where there is capillary atony with leakage of fluid blood is of most temporary value and is rapidly lost from the circulation Possibly the employment of some vitamin infusion may prove of specific value in these cases.

SELECTION OF CASES

In periods of rush and emergency a wise choice may have to be made of the abdominal cases awaiting the consideration of the surgeon. When the ideal of extending the benefits of surgery to all such as might legitimately be expected to profit by operation cannot be attained it will be well to remember in this unenviable yet inevitable task of exclusion Owen Richards's slogan Too high too late and too bad Furthermore, the experience of a quarter of a century ago taught the surgeon that a wound of the belly from a large fragment of missile was almost always

fatal Worthington, however, in the last war had a successful case where a fragment of shell weighing over half a pound was lying loose in the peritoneal cavity, there were two wounds of the ileum and one of the sigmoid I saved another patient, who survived a double resection of bowel and bladder injury produced by a fragment of high explosive weighing just under a quarter of a pound Such cures are exceptional, and cases of this kind should not be given preference over those that are more promising

Those wounded who have extrusion of bowel from the abdominal cavity, especially if this be badly damaged, make poor recoveries They are "bad surgical risks", although their general appearance and condition may deceive the observer, yet a number of marvellous recoveries of this nature, of course, resulted, and the first successful abdominal operation upon the British front concerned a Scotch Canadian who walked back from the German lines with his intestines extruded A successful resection of six feet of small intestine was performed by Owen Richards, and the specimen is in the Museum of the Royal College of Surgeons of England

ANAESTHESIA

Gas and oxygen produced the best results in the surgery of gunshot wounds of the abdomen, the finest statistics of all came from that excellent surgeon D C Taylor, who had the good fortune to be associated with Geoffrey Marshall Not only was the latter a most able administrator of gas and oxygen, but he also taught its use to many of those charged with the duty of giving anaesthetics in the clearing station The badly injured abdominal case proves an easy subject for gas-and-oxygen administration Only a lunatic would employ spinal anaesthesia, but I made much use of supplementary local or regional anaesthesia, unless the proximity of contaminated or septic wounds precluded it Ether gave the best results in the hands of the majority of anaesthetists, and is perhaps the most useful of all anaesthetics The employment of the barbiturates is to be deprecated in those with grave abdominal injury, and reliance

should be placed upon morphine, omnopon, scopolamine, atropine and such well tried pre-operative injections

Speed is the handmaid of success in the operative treatment of wounds of the abdomen, by whatever agency produced. There is no room for the surgical tortoise on the floor of any operating theatre in a casualty station or advanced base which is dealing with gunshot injuries of the belly The captain of a surgical team who lacks the power to hurry wastes his own time and also that of nurses, anaesthetist, and henchmen for not only will he fail to save those wounded men who might have been rescued by one of a faster turn of speed but he will also be debarred by the passage of time from extending help to others who are looking to surgery to save their life and limb

OPERATION

In cases where there is more than one wound it is of paramount importance to deal with those situated on back, buttocks, or the posterior aspect of the lower limbs before the abdomen is opened When a patient has had a laparotomy the act of turning in order to secure ready access to a wound on the back produces a great fall of blood pressure which may prove fatal. This instruction cannot be too firmly insisted upon the hindmost shall be first!

In most cases it will be wise to make a median or paramedian incision of generous dimensions. On opening the abdomen the first step will be to control such haemorrhage as is taking place the bleeding most frequently comes from the mesentery but may originate in a wound of omentum or the bowel itself. The intestine may bleed freely as may the stomach especially the vessels along its curvatures, and also on the walls of the viscus itself The liver spleen, and kidney must be investigated as possible sources of intraperitoneal bleeding in the case of the spleen and kidney it is wise not to remove the injured organ unless haemorrhage is menacing life. A conservative attitude should be especially adopted in the first instance in respect of kidney injuries, and although in a certain number of cases where conservatism has at first been shown a secondary nephrectomy

may prove necessary, a considerable proportion of kidneys are saved

A retroperitoneal haematoma, if leaking into the peritoneal cavity, may demand attention, and severe haemorrhage from the inferior vena cava has been controlled successfully by suture (Sampson), or more easily by one or more pressure forceps applied to the rent in the vein, and left in position for some days with the handles projecting from the abdominal wound (D C Taylor, Gordon-Taylor)

SMALL INTESTINE

The small intestine, as that portion of the digestive tract most liable to injury, must be systematically inspected, coil by coil. It is well to start at the ileo-caecal junction and work upwards to the duodeno-jejunal flexure, on the other hand, the direction may be reversed The surgeon must satisfy himself as to the condition of each loop on the first inspection there must be no second look, after each coil has in its turn been replaced inside the abdomen The patient is already shocked eviseration and rough handling will augment the shock and jeopardize his life

The surgeon must remember the possibility of wounds between the layers of the mesentery, and must examine any haematoma, especially if crepitant, in the vicinity of the duodenum, lest a retroperitoneal rupture of this fixed part of the small gut be overlooked Perforation, or even rents of the small bowel, with the corolla-like eversion of the mucosa (Fig 6), can well be dealt with by simple suture, and this method of repair should always be employed wherever it seems appropriate A single Lembert stitch of silk or thread, on a round-bodied needle, suffices for the treatment of this type of perforation

The pathological anatomy of gunshot wounds of the abdomen is hardly likely to differ, save in degree, from those encountered in the war of 1914–18, but if surgical technique does vary in the future the explanation will be found in the greater shattering effect of high explosive, which is more likely to produce wounds of the intestinal tract necessitating resection rather than con-

servative repair Resection of small intestine should be employed in the following circumstances

(*a*) The separation of the intestine from its mesentery for a distance of over three-quarters of an inch (This understates the figure given by several writers on military abdominal surgery)

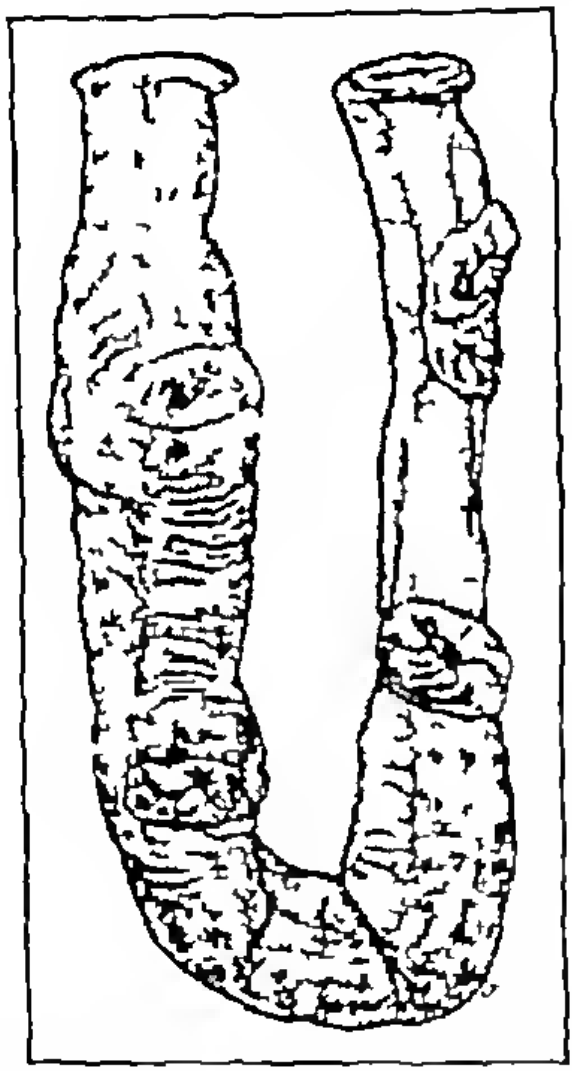

Fig 6.—Penetrating wound of small intestine of gunshot origin, showing the corolla like eversion of the mucosa.
(War Collection, R.C.S)

In the event of severe contusion or laceration of the implicated bowel any mesenteric detachment must be regarded still more seriously

(*b*) Where the proximity of multiple wounds is likely to render the results of their individual suture a mosaic of threads or a

misshapen patchwork, probably resulting in interference with the mechanical function of the bowel

(*c*) In cases of intestinal infarction

(*d*) When the weight of the missile has crushed the life out of the damaged intestinal coil.

(*e*) Where perforations are so numerous and extensive it may be less time-consuming to include all the lesions in one segment of bowel ablated.

The old bogy of the dangerous mesenteric angle was dispelled in the last war, and few operators entertain that surgical respect for the jejuno-ileum which is felt towards the large bowel

WOUNDS OF COLON FROM GUNSHOT AND HIGH EXPLOSIVE

The experience of a single operator may doubtless be capricious, but unfortunately my solicitude, which was awakened by all except the more simple forms of colonic wounds of gunshot origin, seems justified after perusal of the collected results of many surgeons published at the end of the war of 1914–18 In view of the increasing proportion of casualties due to high explosive there is little reason to think that the character of colonic injuries will be less severe or baleful in future campaigns In the more frequent or typical examples of wounds of the large intestine, anatomical considerations played no small part in determining the serious character of the injuries

(*a*) The frequent retroperitoneal situation of one or more of the wounds of this portion of the bowel increased yet did not condone its liability to be overlooked by the surgeon

(*b*) The vulnerability of the retroperitoneal tissues to infection, more especially to anaerobic invasion, added to the gravity of gunshot wounds of the large bowel, the absence of a mesocolon in certain segments of the large gut, whereby the bowel and the lethal retrocolic and paracolic tissues were more closely juxtaposed, increased the potentialities of these vertical portions of the colon for threatening life in the event of wounding

(*c*) Concomitant bruising of the large bowel was often considerable and sometimes extended no small distance from the margin of the actual wound, this phenomenon was encountered

much more frequently than in the case of the jejuno-ileum, surgical suture of the colon was thus rendered less secure and certain. The deposit of fat in the wall of the colon is always fraught with some surgical misgiving and its existence demands watchfulness on the part of the operator extravasated blood in the intestinal coats of the obese engenders a sense of still greater incertitude Isolated bruised areas were often seen on the large bowel and were not infrequently remote from the track of the missile Such contusions varied in depth and surface extent and were of some concern in view of their liability to lead to secondary perforation Prophylaxis against this sequel demanded the most adequate provision for drainage

(*d*) The outer coats of the large gut were sometimes ruptured and stripped back from the underlying intact mucosa this phenomenon was occasionally discovered in close proximity to the track of the missile and at other times might be remote from the actual perforation of the bowel These injuries add to the anxieties of conservative surgery

(*e*) The more fixed portions of the colon contrast with the small intestine in the matter of surgical accessibility, and the exposure of a retroperitoneal wound of the flexures or of the vertical segments of the colon through a mid line incision might be associated with serious technical difficulties.

(*f*) The early escape of fluid faecal material from the lumen of the large bowel in cases of gunshot injury was more frequent than from the small gut and its occurrence augmented the gravity of the prognosis a peritoneum inundated with a flood of highly infective fluid from the intestine the extraperitoneal tissues or psoas muscle soaked and sodden with escaping bowel contents, rendered efforts to save the patient fruitless and wasteful of time

(*g*) Infarction was more often met with in the large bowel than in the small intestine in cases of gunshot wounds such cases demanded drastic rather than conservative measures.

METHOD OF SURGICAL APPROACH

I have always had a predilection for incisions made directly over the portion of the colon which demands surgical interven

tion, thus I have made frequent use of flank, iliac, or even subcostal incisions, in which the muscles of the parietes are divided in order to ensure adequate exposure of the field of operation Such avenues of approach reduce to a minimum the anxieties of handling wayward small intestine, and the dangers of generalized contamination of the peritoneal cavity are thereby reduced

In the case of "through-and-through" wounds of gunshot origin far out in the flank or iliac region, where any injury to the abdominal contents seems problematic, or where the outer border or posterior surface of the colon is the most likely site of visceral injury, a lateral incision may perhaps be profitably utilized, yet there can be no certainty about the anatomical disposition of the abdominal viscera, and it must be remembered that on the left side of the peritoneal cavity the descending and iliac portions of the colon are often overlapped by coils of the small gut In most cases the surgeon will therefore be wise who primarily utilizes the mundane median or paramedian incision, so that he can assure himself beyond a doubt of the presence or absence or amount of damage within the belly Should the position of a colon wound revealed by laparotomy render the injury inaccessible to surgical suture or to other treatment through a midline incision, or should provision for adequate drainage appear desirable or imperative, approach can then be made by a supplementary incision in the flank or at the periphery of the abdominal wall If there chance to be wounds of entry or of exit in flank or iliac fossa or over some remote corner of the abdominal cavity, such may be carefully excised, enlarged, and converted into a more convenient avenue of surgical approach to the injured abdominal area

In deciding in favour of the preliminary median or paramedian incision it must be remembered that in not more than 60 per cent of the cases of injury to the large intestine is the colon the only segment of the alimentary canal involved In 40 per cent large-intestine injury is complicated by lesions of other hollow viscera No risks must be taken therefore the operator must make absolutely sure

If preliminary laparotomy reveals no intraperitoneal injury, great care must be taken not to convert a small or uncomplicated extraperitoneal wound of the caecum or the vertical colon into one which implicates the general peritoneal cavity Such smaller wounds may be trimmed and sutured from a posterior approach, provision being made through the muscle-cutting flank incision for drainage of the contaminated area

TREATMENT

The treatment of gunshot wounds of the large intestine will, of course, vary with the anatomical and pathological character of each individual injury the surgical measures adopted may also be dictated by other considerations, such as the coexistence of multiple injuries, concomitant haemorrhage, etc

Small intraperitoneal wounds of the caecum and colon merely require suture but in the case of this part of the bowel there is not the self-same confidence in the efficiency of a single suture that obtains in small intestine injury and most surgeons will employ a double layer of sutures. Greater confidence will be felt if a graft of omentum or an appendix epiploica can be utilized to reinforce the suture line. Most of the successful cases of gunshot injury of the large bowel are of this type.

The more frequent and typical gunshot injury of the colon has many or most of the characteristics that I have already described most of the wounds are associated with greater contusion than obtains in the small bowel infarction is more frequent, and the adjacent extraperitoneal tissues of the postero-lateral wall of the abdomen are the seat of a haematoma, certainly contaminated, perhaps already gravely infected with organisms which may have been introduced with the missile or may have been denizens of the lumen of the injured intestine. In some cases the wounds are large and gaping they are rarely multiple, but the damage and tearing of the coats of the caecum or colon render local suture unpromising

Indications for Resection

I therefore find myself in disagreement with those who deny a place for resection in the case of colon wounds. I am convinced

Shaw Dunn first drew attention This very rapid gangrene of the mucous membrane seems to be caused by the deprivation of its blood supply through the rupture of the small vessels and laceration of the underlying muscular coat of the bowel produced by a missile, the actual track of which may be some distance from the intestine In these bursting or traction injuries the gangrene of the bowel leads almost at once to a severe infection of the retroperitoneal space Colostomy can be of no more service in this class of case than the performance of an enterostomy in the treatment of a gangrenous appendicitis

It is in such wounds that heroic measures must be employed freely to explore, drain, and possibly excise the damaged area of the bowel Portions of the innominate bone or the coccyx may require removal to effect a thorough exposure of the rectum and the post-rectal tissues

WOUNDS OF STOMACH AND URINARY BLADDER

Gunshot wounds of the stomach vary greatly in size and appearance, and usually involve both surfaces of the viscus Suture will be employed as a rule, but the incidence of secondary haemorrhage during convalescence, often of fatal nature, raises the question of the desirability of excision of the damaged portion of stomach wall, when this is in an accessible position and the general condition of the patient does not negative such a step In certain cases distortion, or uncertainty as to reliable closure of wounds of the pylorus, may suggest a supplementary gastro-enterostomy

Gunshot wounds of the urinary bladder may be intraperitoneal or extraperitoneal, both surfaces of the bladder may be implicated This last-mentioned form of lesion is common in buttock wounds, and may be complicated by a fractured pelvis and injury to the intestine Suture of intraperitoneal wounds is easy, extraperitoneal wounds should be sutured where possible, and a corrugated rubber drain may be inserted, if uncertainty be felt as to the security of the suture In some cases a self-retaining suprapubic catheter may be used with advantage

PENETRATING WOUNDS OF THE SOLID VISCERA

The Liver.—The dimensions of the missile play no inconsiderable part in determining the type of hepatic lesion, which may take the form of a perforation, possibly with cracks and fissures radiating therefrom, a superficial "score" a ragged wound, or a craterform cavity The liver is damaged in practically every abdomino-thoracic wound on the right side of the body and may be badly shattered in such injuries as the 'stove-in chest. The whole organ may be disrupted even by a bullet wound and as much as one-third of the right lobe has been found loose in

Fig 7.—Penetrating wound, traversing liver from right lateral surface to left border; the impossibility of mechanical excision and disinfection of such a track is obvious. (War Collection, R.C.S., 996.)

the peritoneal cavity Examination of museum specimens illustrating gunshot injuries of the liver reveals lesions for which surgery is futile It would be impossible to prevent infection by surgical measures throughout a long ragged track running from one lateral surface to the extreme pole on the other side of the body (Fig 7) and surgical zeal would be entirely misplaced and probably harmful. The escape of important structures in the portal fissure and in the liver substance is sometimes remarkable, and the fatal ending is often due to damage to other structures.

I cannot agree with certain German writers who state that the opening of the abdominal cavity is indicated not only in every certain case of liver injury but also when such an injury is merely probable" If injury to other viscera can be excluded,

may be exposed and dealt with through a paramedian incision, a Perthes incision, or by an abdomino-thoracic approach in injuries invading both cavities of the body

The Pancreas—Penetrating wounds of the pancreas were less frequent in the war of 1914–18 or at any rate less often recognized, than injuries of any other of the abdominal viscera. The intimate anatomical relations of the gland to the large blood vessels are such that a wound of the pancreas involves the greatest risk of an immediate severe and probably fatal haemorrhage Many wounds of the pancreas doubtless never reached an abdominal hospital, and in such patients as survived to reach an operating theatre the lesion may have been overlooked by surgeons more intent on dealing with injuries of the hollow viscera, or the cases were designated retroperitoneal haematomata" Successfully treated cases of gunshot injury to the pancreas were certainly recorded by Richard Charles (two) Lockwood, Saint, Mayo-Robson (two) John Morley myself (three) and others.

ABDOMINO-THORACIC INJURIES

Increasing familiarity with the problems of the surgery of warfare, and especially the radical treatment of the more severe injuries of the thorax for which British surgery is under a special debt to George Gask, gradually led to a diminution in the mortality from these wounds as the years of the great war went by In 1916 only 18 per cent. of these cases were saved but in November 1917 Sir Anthony Bowlby was able to report a recovery rate of 49 per cent. In the autumn of 1918 I collected the results of 207 operations for abdomino-thoracic injury performed by six surgeons in the Fourth British Army (Jack Anderson, Saint, Stanley Walker Hancock Gordon Taylor) when the recovery rate reached 66·6 per cent. and in the case of Saint of Capetown and the late Jack Anderson was no less than 80 per cent. The individual results depend very largely upon the involvement of hollow or solid abdominal organs in the complicated injury the latter type of wound produces a much lower mortality rate, but even in the case of involvement of a hollow viscus I had a 30 per cent. rate of recovery

The treatment of abdomino-thoracic injuries may be outlined as follows:

(*a*) Where there is a through-and-through abdomino-thoracic wound on the right side, inflicted by only a small fragment, no active surgical treatment may be required

(*b*) Where there is an abdomino-thoracic wound on the right side, and a small fragment is retained in an inaccessible position in the liver, an expectant line of treatment is the correct procedure

(*c*) Where there is a small wound in the thorax, and there is evidence of abdominal injury demanding operation, the belly has priority in the matter of surgery, and should be approached by median, paramedian, or some appropriately placed incision. The thorax may require no special attention.

(*d*) Where there is a through-and-through wound involving thorax, diaphragm, and abdomen, and associated with severe injury to the thorax, the thoracic wound should be dealt with first, and an approach to the upper abdomen made through the diaphragm.

(*e*) Where there is a wound of entry in the thorax, inflicted by a large- or moderate-sized fragment of missile, which is retained, a radiograph is most valuable. The thoracic injury should again be dealt with first, and the abdomen approached through the diaphragm.

(*f*) In some cases, where the wound of the thorax is low down, access to supra- and infra-diaphragmatic areas may be obtained by cutting through the costal arch after the manner of Bland-Sutton, Duval, Kirschner, etc.

INJURIES WITHOUT PENETRATING WOUND

Injuries of the abdominal viscera may occur without penetrating wound. The demolition of buildings by air bombardment, with bricks, mortar, iron, and timber confusedly hurled by explosive force against the abdominal wall, may rupture intestine or rend the liver without any breach of the skin. Severe damage to the contents of the coelom may even be produced by mere explosive force without any impact of debris on the abdominal parietes.

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In the surgery of everyday life it is affirmed that severe contusions of the abdominal wall are not often associated with internal injuries the blow that expends itself in disrupting the muscular layers of the parietes is said to be too far spent to exert its baleful action on the digestive tube or the solid abdominal organs. No reliance is to be placed on such probabilities or possibilities in the damage inflicted by high explosives. I have no intention of enumerating all the signs and symptoms which point to damaged intestine in contusions of the abdomen the late W H. Battle, Sir James Berry and Zachary Cope have all made signal contributions to our knowledge of this subject. Perhaps the most cogent reason for laparotomy in these cases of suspected gut injury is doubt and where any uncertainty exists the surgeon should open the abdomen at the earliest moment When unmistakable signs of peritonitis manifest themselves the golden opportunity has been lost the patient is already doomed and operation is only an agonal necropsy

The surgical diagnosis and treatment of haemorrhage from the solid abdominal viscera are well known to all operators. An adequate exposure of the convexity of the liver in order to deal with liver bleeding may be impossible through the usual median incision. The removal of the cartilage of the costal outlet may be drastic but emergency may demand the heroic the adoption of this procedure has certainly been successful on rare occasions in my hands Temporary control of the bleeding by compression of the structures in the free edge of the gastro-hepatic omentum has been stressed by Hogarth Pringle and Grey Turner

LAPAROTOMY INCISIONS AND DRAINAGE

Drainage of the Abdominal Cavity—Where any doubt exists as to the propriety of drainage it is better not to drain. Drainage tracks are prone to become secondarily infected with streptococci in hospitals on the lines of communication sometimes with disastrous results

Closure of the Abdominal Wound— Through-and-through' sutures save time but should be used only on exceptional occasions a carefully closed peritoneum affords some protection

against the spread of infection from the abdominal wall to the coelomic cavity In cases where large masses of the rectus abdominis or the lateral muscles of the abdomen require incision because of infection or threatened infection with gas gangrene, the space resulting may be temporarily filled with gauze soaked in some antiseptic such as eusol, flavine, etc , which is left in place under the sutured skin and removed only when it is felt certain that the parietal peritoneum is securely healed A temporary buffer is thus provided between the intestines and the outside world!

WAR INJURIES TO THE GENITO URINARY TRACT

By G E NELIGAN M C F.R.C S

Looking back on the experience of the last war during which I was for two and a half years in a clearing station performing abdominal surgery the thing that strikes me was the comparative rarity of wounds of the kidney or the urinary tract When we consider the hundreds of abdominal cases on which we had to operate the infrequency of kidney wounds appears remarkable. The reason for it I do not know, except that injury of the kidneys, relatively small organs might be missed among the more extensive and obvious abdominal injuries which reached the clearing station The injuries were those caused by machine-gun bullets, shrapnel bullets, and high-explosive shells In the next war regarding the matter from the point of view of civilian injuries, the damage caused by the high-explosive bomb and the crushing injuries due to falling masonry will also have to be considered.

One thing which we discovered in the last war was, in general, the uselessness of operating on patients immediately they were brought into the station. Many men shot in the abdomen were received in a terribly collapsed condition and at first were operated on immediately and of course they died The better way was to take some measures of resuscitation, warming them, and relieving their pain and then when they reached the optimum period of improvement, to carry out the operation. The habit of detecting such a period was acquired, for it was usually found to be a couple of hours after the case was brought in. If one waited longer than this the patient began to go downhill again.

known, so that it may be possible to explore the whole abdomen from the stomach down to the rectum.

Sometimes it is found that no injury has been done to the intestines themselves although the patient when examined showed all the signs of an intraperitoneal injury There may be extensive retroperitoneal haemorrhage These patients always suffer a great deal of shock, pain and distension In such cases the kidney is dealt with in the best way possible, with drainage lest there be an infection of the retroperitoneal tissues. If the kidney itself is badly damaged with extensive haemorrhage around it, it will be necessary to carry out a nephrectomy No time is available in these cases to risk doing what may be called fancy operations With these abdominal wounds the chief factor is speed, partly from the patient s point of view and partly because of the pressure under which the work has usually to be done

In the majority of cases, therefore, where the kidney is severely damaged a nephrectomy has to be performed Occasionally the surgeon may have the fortune to come across a case in which the damage was done only to the periphery of the kidney in which event he is justified in suturing, and may hope to save it. Injuries to the pelvis of the kidney are treated as in civil life. If it is possible the pelvis is sutured, but if it is completely torn away then again a nephrectomy is necessary

WOUNDS OF THE URETER

Wounds of the ureter were also very seldom seen in the rush of war injuries. We may of course come across them afterwards on opening up the abdomen, though they had never been diag nosed at the time. In opening an abdomen full of blood and faeces it is essential as quickly as possible to suture the rents in the intestine or to resect as necessary and in these circumstances the ureter is hardly likely to be seen even if it is damaged. Basil Hughes, who worked at Salonika, had seven or eight cases, I think which developed urinary fistula as a result of the wound of the ureter His advice was to leave them alone as in his experience the fistula practically always healed up

Turning now to injuries caused by falling masonry, we may get a patient with a crushed wound in his loin, with symptoms limited to haematuria and no signs of any intra-abdominal damage or internal haemorrhage. In such a case the patient would obviously be left alone and the effect of rest in bed be observed The only circumstance that would make it necessary to interfere in these cases in which the whole condition appeared to be extraperitoneal would be very severe haematuria that refused to stop after treatment and the development of a large lump in the loin, due to perirenal haematoma In that case it would be necessary to explore the loin and almost certainly carry out a nephrectomy. To decide as to the function of the other kidney, the simplest expedient is the injection of indigo carmine and a rapid cystoscopy before the operation is done

In some civil injuries of this kind the haematuria ceases and then starts again within a day or two ; or even at a later period, after the patient has got up, there may be recurrent attacks of haematuria Faced with a condition of that kind the kidney must be thoroughly examined, with the aid of either an intravenous or a retrograde pyelogram, to see if any abnormality is keeping up the haemorrhage. I have observed this take place two or three times when the underlying source of trouble proved to be a hydronephrosis that had been injured.

One case of the kind was that of a boy who, while playing rugger, received a kick in the loin. He kept on bleeding and proved to have a large hydronephrosis, though he had had no previous symptom.

Another case I recall was that of a big-game hunter in East Africa, one of the finest-looking men I have ever seen. While going down a narrow glade he was charged by an elephant, and. stepping back behind a tree. he tripped and fell down on the ground. The elephant gave him a jab in the abdomen with the base of its trunk. but by that time one of the bearers, firing his rifle. frightened the elephant away The hunter was taken on a stretcher made of some branches to the local missionary station thirty-six hours' journey distant, and by the light of the moon that night he discovered that he was suffering from haema-

turia. The condition settled down, he came back to England but continued to have several more attacks of haematuria and on examining him I found perhaps the largest hydronephrosis I have ever seen.

I stress this matter only in order to suggest that in a case of renal injury with persistent bleeding the kidney should be investigated for any underlying cause responsible for keeping up the haematuria.

Obviously with an infected perirenal haematoma we would have to open and drain. That may well be done later in the proceedings, not at the time of the injury In the case of a person who has had a crush injury of the abdomen and is suffering from haematuria, with all the signs of intra-abdominal damage with rigidity pain or symptoms of intraperitoneal haemorrhage there would be no alternative but to perform a laparotomy and explore the kidney and almost certainly a nephrectomy would be necessary The other intra abdominal injuries, such as ruptured spleen liver or intestines would also have to be dealt with

BLADDER INJURIES

In the case of men shot through the lower abdomen and the bladder by bullets during the war most of the injuries were intraperitoneal rupture of the bladder although in some cases both intraperitoneal and extraperitoneal injuries were found Here occurs the added difficulty in that there may be rupture not only of the bladder but of the intestines, and also severe splintering damage to the sacrum or the bones of the pelvis. That is more likely to happen with a jagged high explosive than with a bullet, which may go straight through. The entrance and exit wounds may be found, but the patient remains unable to pass urine If a catheter be inserted only a little blood-stained urine may be obtained. A diagnosis of bladder injury is then made, and the first thing to do is to excise the wound. If there are signs not only of perforated bladder but of intra-abdominal injury as well, then a laparotomy should be performed. The injured peritoneal wound in the bladder is found and sutured, the injuries to the rectum or small intestine are dealt with, and

then either a catheter is tied in or the peritoneum is stripped back and a self-retaining catheter inserted suprapubically—the abdomen, of course, being mopped out If there is severe damage to the bones of the pelvis and sacrum it is absolutely essential to excise these wounds and remove any bony fragments that are lying about If the wound is found communicating with the bladder the bladder should be opened and an endeavour made to suture it from the inside A tube is then put down through the excised wound to the bladder, and the rest of the wound sutured as much as possible, after which the bladder is drained suprapubically These are the cases in which the damage is caused by fragments of shell or pieces of bone that have not entered the peritoneal cavity Drainage must always take place in these cases, not only suprapubically but from the entrance or exit wound made by the foreign body The result may be successful and the whole condition be cleared up On the other hand, some of these cases, while they show healing, are left with various fistulae I saw one ex-soldier who passed his urine partly through his urethra, partly through two suprapubic fistulae, and partly near the site where his ischial tuberosity used to be His injury was sustained in the war, and he is living a fairly normal life

If the wound is extraperitoneal and the patient is tender suprapubically, on passing a catheter through the entrance wound a fair amount of blood-stained fluid will be found The thing to do is to excise the wound and track down to the bladder, we may then have the fortune to find in the bladder itself the fragment of shell In that case it is removed, a Malecot tube is put in, and drainage instituted If the bullet has gone right through it will have damaged the rectum or the bones of the pelvis In a case of severe damage to the rectum itself the safest thing is to perform a colostomy temporarily while there is a chance for the wounds below to heal up, because there is no chance at all so long as faecal material is passing over the lacerated wounds It is always safer to drain a bladder suprapubically than to tie in catheters, especially in the conditions under which war casualties have to be attended The patient may have to undergo a long journey after the operation, and the surgeon never

knows whether the catheter may not get blocked or kinked. On the other hand, the suprapubic self retaining catheter is always safe

Crushing wounds of the bladder in war are very much the same as those encountered in civil life in road accident cases, and the injury of the bladder is usually produced by a fracture of the pelvis The fractured ends of the bone may be driven into the bladder Here again the bladder may be ruptured intraperitoneally or extraperitoneally In the former case one finds pain, rigidity of the abdomen, and inability of the patient to pass urine When the catheter is inserted a little urine is obtained. If a small amount of sterile lotion be injected through the catheter very little of it comes back. In that case a laparotomy is performed the intraperitoneal rupture is sutured the abdomen is mopped out and closed The safest plan is to strip back the peritoneum and insert a self retaining catheter through the trocar and cannula.

On the other hand if the damage is extraperitoneal we may find the bladder palpable, and on passing the catheter obtain a good deal of blood stained urine. I have employed cystoscopy on one or two occasions to confirm the diagnosis and could see the rent at the top of the bladder In cases like that a suprapubic procedure is carried out the hole in the bladder found if it is anywhere in the median line, the self retaining catheter and Malecot tube inserted and the wound sutured around it. The Malecot tube can be taken out after a week.

In considering the bladder the further question of a fractured spine arises. In war there are many fractured spines and there will probably be a great many more in air raids, as a result both of direct wounds from bombing and of falling masonry

The question how to treat the fractured spine from the bladder point of view was one that obtained a great deal of consideration during the war and much varied counsel was given, some of it of a kind that was obviously foolish. Indeed, we were always getting new directions from the base as to what we were to do when a man came in with a fractured spine or pelvis and a distended bladder First of all we were told that such a case was

The same principle applies to wounds in the testicle Either they were through-and-through wounds which were not bleeding and in which no particular damage had been done, or else they were lacerated wounds of the scrotum out of which one might have a testicle herniating They were treated exactly as civil injuries, the wound being excised, the testicle removed, and suturing being done

even the necessary pre-operative x-ray study of each case may be omitted (a serious blunder). This matter is important for two reasons at least: first, because the mortality of head wounds is distinctly lower in the hands of those who understand them; and, secondly, because the residual disabilities are less. It is only too easy to increase damage to the nervous system by injudicious operating, and so to leave to the community's charge a permanently crippled individual. There will be enough of those, whatever happens and whatever their injury; we must plan, so far as possible, to keep their numbers low.

Not only is the arrangement of teams necessary, but they cannot proceed properly without the correct instruments. The general nature of these is standardized, and they are easily obtainable. Without them proper work cannot be done: the old hand-trephine and bone-nibbling forceps of ancient pattern are not conducive to good work.

NEURAL DAMAGE AND NEUROLOGICAL SIGNS

A man may die of a head wound from different causes or from a combination of several factors—sometimes from haemorrhage from the great vessels of the brain and dura, from injury to vital centres in the brain-stem and more often in the hypothalamus, from consecutive cerebral oedema; or, if he survives these things, or if the site and nature of his wound exclude these others, from septic encephalitis and meningitis. A wound of the head usually leads to some disturbance of function, but circumscribed wounds do not cause unconsciousness. Indeed, the greater number of the patients have suffered only a temporary loss of consciousness, and examples of dural penetration are to be found amongst the walking wounded. On the other hand, a comatose patient may or may not be going to die, as may one with lighter damage perhaps more heavily infected. The clinical disability at the time depends on the purely chance factor of the site of the injury its depth and direction. There will follow the physiological deficit proper to the cerebral area injured and it is essential that the signs should be noted [illegible] position of the wound of entrance and [illegible] of the

direction of penetration. In this way the surgeon comes to have a clear picture of what he intends to do, and in this way too, he can follow the course of the case intelligently afterwards. An increase in the signs a few days later may indicate the formation of an abscess, but if the surgeon has no record of the early state he will have no means of interpreting the new features.

No greater mistake can be made than to think of a gunshot wound of the head as a pure exercise in operative technique without reference to neurological signs. Unless this creed is fully and conscientiously accepted we may see patients come to the operating table without any previous study And if that happens, how is the surgeon to know whether a superficial injury of the bone a groove in its surface or a fissured fracture requires trepanation? More important still, how is he to know whether the dura should be opened? A decision on this point is never very easy but it cannot be made on local appearances alone It is the presence or absence of signs of intracranial disturbance which is the deciding factor The use of the protective helmet allowed soldiers to suffer blows upon the head which would otherwise have killed them outright. But, although life is saved, the violence of the blow not uncommonly caused a contusion of the cortex which led to weakness of an arm or of a leg or to a hemianopia even beneath an unbroken skull. The occurrence of Jacksonian epilepsy or of an aphasia after a proved pure scalp wound tells a story in this connection which all may read. I published a series of cases which gave evidence of outspoken neurological signs after scalp wounds without damage to the skull, as proved both by *x* rays and by exploration. The fact that these cases existed in fair numbers sufficiently underlines the point I wish to make.

An important aspect of this question is that of *consciousness* and *unconsciousness* If a casualty is unconscious the omens are bad. The reason is at once apparent if we compare the effects of the closed fractures of the skull of civilian practice with localized open injuries. In the former the whole brain has been submitted to violence so that loss of consciousness for a greater

or lesser length of time is the rule. In local injuries no such generalized effect is to be expected, and most soldiers with head wounds spoke of having been at most temporarily stunned, even when the dura had been penetrated and even when a shell fragment was embedded. If, therefore, a patient with such an injury is unconscious the indication is that severe damage has been inflicted on the brain by the missile In the casualties which survive to reach the surgeon the wounds are not always very deep, and the patient, though he may be confused, is often conscious The wounds can be graded (Cushing) according to severity thus :

1. Scalp wounds
2 Wounds with superficial damage to the skull
3. Wounds with severer injury to the bone but without dural penetration
4. Wounds with injury to scalp and bone, with the dura torn.
5. The same as before, but with bone fragments in-driven and sometimes a retained missile
6 As before, but with the fragments reaching the lateral ventricles.
7. Perforating wounds, through and through the head
8 Penetrating wounds or perforating wounds opening the mastoid or paranasal sinus (cranio-facial or cranio-mastoid injuries)

Positive neurological signs may be present with even the simplest-looking injuries. I repeat this point, however obvious it sounds in relation to some of these injuries, because it is so important Neural disabilities, when present, put a certain onus on the surgeon, who must do his best not to aggravate them by his treatment of the wound, and on the nursing staff in after-care A hemiplegia, for example, needs special nursing attention, even more so does an unconscious and restless patient An aphasia complicates the picture by making it difficult for the patient either to communicate his symptoms or to declare his wants But all these original injuries will be worsened and be made permanent if infection develops

CONTAMINATION AND INFECTION

In general, operations are performed on wounds of the head because the patient can only in that way be relieved of such symptoms as he has, and because we know by experience that if no operation is done he runs a serious risk of dying from sepsis, whatever his original signs may have been, little or great. It comes to be the case therefore, that the operation is planned both to relieve him neurologically and to prevent infection. The two desiderata are interlocked for infection will increase his disablement even if he survives. The experiences of the last war made it clear that whereas various antiseptics had their uses none was so potent that it could compete with the earliest possible and most complete excision of the wound as the ideal treatment In head wounds this must remain a counsel of perfection, for a complete excision of contused and contaminated scalp and skull cannot be extended to the dura and brain This is not so grave an obstacle to the patient's recovery as might be expected for with skilful treatment of the more superficial areas the brain has an opportunity to deal with the injury its powers of overcoming infection are considerable once devitalized tissue and foreign bodies have been removed. The worst cases will be those with a deep wound with a projectile lodged at a depth, whence bacterial spread may reach the lateral ventricle. It can be accepted as a fact that all wounds are contaminated, and the longer they are left unexcised the greater the risk of the subject's death from sepsis. In-driven bone fragments are a potent source of something worse than mere morbidity all should be removed. During the last war I had cultures taken from them, and they were always infected, sometimes with *B welchii*

I have nothing except unfavourable things to say of leaving head wounds untreated for two or three days, although there was a time when that policy was advised It was based on imperfect understanding of the subject. The mortality of gunshot wounds of the head is found to rise step by step with the time that has elapsed between the receipt of the wound and the operation. The death rate is notably higher where operation

has been delayed beyond twenty-four to thirty-six hours In times of great stress such delays are unfortunately difficult to avoid, but the ideal of the earliest possible operation in order to minimize sepsis must always be borne in mind This necessitates careful planning of transport and operating facilities by the administrative staff

DURA MATER AS BARRIER TO INFECTION

The dura mater is the important barrier against the spread of infection to the brain, when it is intact the prognosis is good, and when it is torn the outlook is more serious All cases can therefore be divided into two large prognostic groups according to the integrity of the dura mater, in times of emergency it may be difficult to decide which group to operate on first—the cases of greater urgency or those which are more likely to make a good recovery

There is a tendency to plan treatment for the most severe injuries, assuming that these are much the most common. But in a series of 220 cases which I reported after the great war there were 54 pure scalp wounds, 53 compound fractures without dural penetration, and 113 with laceration of the dura There was no mortality in the first two groups, all the patients having been operated upon I can recollect, however, that deaths were reported elsewhere in some cases without dural penetration The cause of death was either severe cerebral contusion or the late development of a cerebral abscess In the penetrating group the mortality was 37 8 per cent This is a very much higher mortality than that of civilian depressed fractures with dural tears and cerebral laceration The reason is that the civilian cases are cleaner bacteriologically and that the injury is more superficial, even though it may involve a considerable surface area.

X-RAY EXAMINATION

Even in difficult times it was usually possible for radiographic pictures to be taken. Unless it is known for certain not only whether a missile lies within the skull but where it is and what is its size, it is impossible to operate except in a haphazard way

To search for a foreign body that is not there is as bad as or worse than leaving one behind. A missile may have penetrated the falx and be in so silent an area of the opposite hemisphere that its presence could not be suspected until infection caused it to declare itself too late to allow of useful treatment. Nor is it the wounding missile alone about which information is sought. The number and position of in-driven bone fragments has to be accurately charted, for only thus can it be known what is to be done and in what direction the fractured portions are to be sought. With this information and with the knowledge of the clinical signs the operation may be intelligently commenced.

PRE-OPERATIVE PREPARATIONS

No case should be operated on until recovered from primary shock. This is rarely present in local wounds of the skull (though common in the first stages of closed injuries) unless it be due to exposure or loss of blood from the vascular scalp The condition of the patient can be greatly altered for the worse by the presence of associated injuries it may be these that sway the balance against him rather than the head wound.

Head injuries rarely call for blood transfusions in healthy soldiers, but multiple injuries may necessitate it, and blood will be available chiefly from the blood banks. It might be more needed for civilians There may be difficulty in deciding which injury is most in want of operative treatment but, faced with the actual case the urgency of one particular wound will generally declare itself If the patient is fully conscious, or very restless but not comatose, he should be given an injection of omnopon 1/3 grain and scopolamine 1/300 grain an hour before the operation. The amounts of the drugs must be decided, of course, by the general condition of the patient in a cyanosed or uncontrollably restless man they will be omitted and an ether anaesthetic administered Just before the operation when the patient is sleepy the whole head should be shaved local shavings often lead to inadequate exposures and difficulties in post-operative dressings. Before this time careful radiological studies of the wound ought to be made.

ANAESTHESIA

Local anaesthesia is by far the most satisfactory method A 1 per cent solution of novocain with five drops of adrenaline to one ounce of the solution should be injected under the galea until a wheal half an inch high is raised, at first it should be so injected that the whole of the planned field is enclosed, further injections can be made if the primary incisions need enlarging Apart from the large meningeal vessels and the basal dura mater, the whole operation field will be rendered insensitive The temporal muscle should be liberally infiltrated if the operative field encroaches on this region It is a wise plan to infiltrate the scalp widely, because incisions often have to be carried further than is at first apparent

POSITION ON THE TABLE

The patient should lie comfortably on his back or face, according to the position of the wound, the head should be slightly raised above the level of the rest of the body to prevent venous congestion and turned to the appropriate side. His wrists should be tethered to the table but given two or three inches of freedom, and the towels be so draped that he has a free air-way Restlessness under local anaesthesia is often due to a feeling of suffocation or to overheating, and these two things must be avoided The field of operation must be easily accessible if unnecessary difficulties are to be prevented Correct positioning on the table marks a distinction between those who are experienced in injuries of the head and those who are not A tray for instruments should be placed across the table, clearing the upper part of the patient's chest by some six or more inches Such a tray may be fixed to the table as part of its mobile equipment or be on a stand alongside By draping the towels over it a tent is made, allowing of access to the patient's mouth and nose Oxygen can be given by pinning a funnel attached to a cylinder to the covers inside this tent An arrangement of this sort is most important If towels are wetted in mercury perchloride solution, or become wet as the operation proceeds and

cling about the patient s face they cause him such respiratory embarrassment that it will be impossible to do good surgery There is much in favour of using wet towels, wrung out of 1 in 2 000 mercurial solution in place of the dry ones usual in civilian aseptic surgery Four should be arranged to leave a square enclosing the operation field Wet towels are more easily draped to the contour of the head and do not slip easily A stitch or two may be used to fix them. Practice teaches how best to do this. All towels are arranged to run off the patient s head on

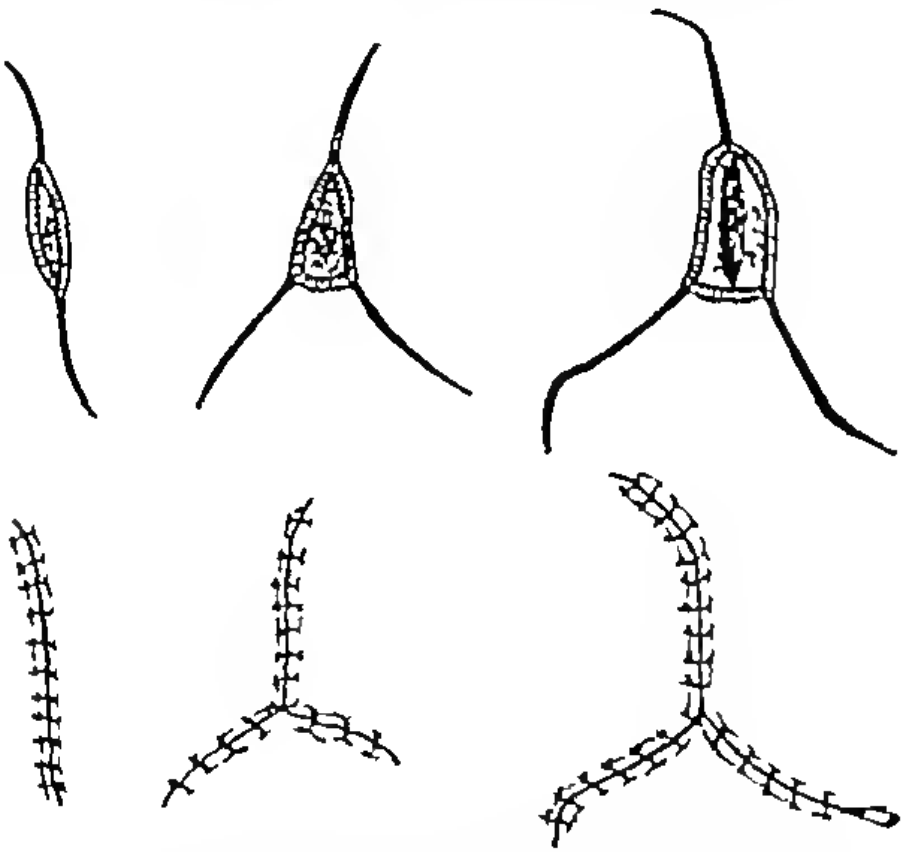

Fig 8.—Showing Incision of Scalp Wounds.

to the tray before mentioned and the whole covered with a dry sheet with an opening eight inches in diameter near one end to give access to the wound

THE SCALP

The incision will necessarily be determined by the shape of the scalp wound its dimensions will depend on what is required for the exposure of the bone or brain. The edges of the scalp

wound must be sparingly excised, and it is in this phase of the operation that excessive blood loss may take place if the skin is not adequately exsanguinated by digital compression until bleeding points can be controlled by haemostats If no deeper injury is disclosed no more is necessary, but when the excision is only the first step in a bigger operation, extension will be needed

It is the custom in surgical textbooks to display diagrams of plastic incisions to allow of the closure of scalp wounds Most of these are bad. It is a simple enough matter to illustrate long tension incisions through the whole thickness of the scalp to allow of wound approximation, or to indicate sliding flaps of different sorts with the same object In practice, however, each incision leads to severe bleeding, and there is no way of stopping it except by sewing the skin of the gaps down to the galea—a tedious and unsatisfactory process Indeed, the briefest experience with such methods leads to their abandonment

The triradiate has been proved the most generally useful incision (Fig 8) Its advantages are that an adequate exposure can always be obtained, the minimum of gape occurs if the wound breaks down, and drainage tubes can be conveniently placed A glance at the diagrams will make the principle plain, the sketch illustrates the very long incision needed to close some wounds, but not all Any type of incision except the triradiate will rarely be needed Semicircular skin flaps such as are made in neurosurgery for the turning of osteoplastic flaps are best avoided They may have to be used in the temporal and occipital regions where the triradiate incision is unsuitable, as a limb would have to be carried on to the face or neck In the former the limb is cosmetically bad, in the latter the tissues are stiff, fatty, fibrous, and vascular.

THE SKULL

The treatment of injuries to the skull is a relatively easy problem depressions should be raised and loose fragments removed rather than replaced because of the fear of infection, calvarial defects can be repaired without difficulty at a later date A

depressed fragment is best approached through a burr hole sunk over the sound skull 1 5 cm. from the edge of the defect the advantage of this manoeuvre is that normal dura mater can be defined with certainty and from this start its torn edge can be identified and followed around the wound Unnecessary damage to the dura is often done with the nibbling forceps if the fractured

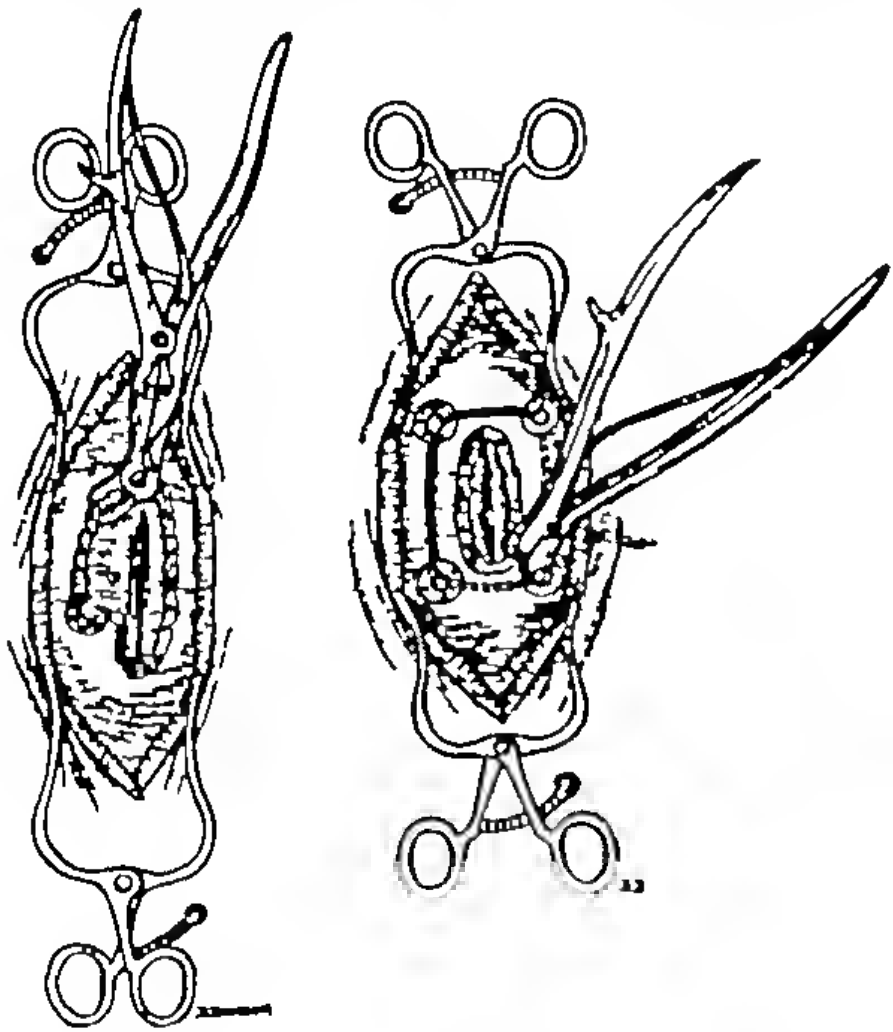

Fig 9 —Alternative methods of bone removal.

edge is attacked directly Depressed interlocked fragments are to be removed by a block resection, burr holes being sunk at four points in sound skull around the depression and these connected by linear cuts made with a Gigli saw de Vilbiss or Montenovesi forceps (Fig 9) If double-acting bone-nibbling forceps of the Stille pattern are not available it is better to use block resection. The older kinds of rongeurs jar the patient

uncomfortably and make him restless Probably the chief advantage of block resection is that it is more apt to ensure a sufficiently wide removal of the bone around the injury. A margin of at least 2 cm. should be cut all round the dural laceration

What should be done with a linear fracture? The answer depends on another question What are the subject's neurological signs? If there are none, and if there is no foreign material jammed in the crack, it may be left alone But if signs are present the bone must be burred through and possibly the dura opened

Fractures of the base with the dura torn opening into the middle ear are serious because of the danger of meningitis developing The external auditory meatus should be swabbed clean, never syringed, and a wisp of carbolic gauze packed in very lightly; the external ear and face should be cleaned and covered with a large sterile dressing Pneumococcal infections may arise from coincidental injury of the paranasal air sinuses Fortunately these wounds are not common, for they are serious. It is better to remove sparingly the anterior wall of the frontal sinus if it is injured.

THE DURA MATER

The question will often arise whether the dura should be opened. The reader should know now what the answer will be If there are definite signs of intracranial damage, if the patient has localizing signs, if he has severe headache or is more stuporous than he should be, the dura should be incised This should more certainly be done if the dura is dark blue in appearance, for this indicates blood beneath it An incision will lead to its release and often to something more—the extrusion of pulped brain tissue This should be washed and sucked away and then the dura closed again Closure is important, for otherwise a superficial infection of no great virulence in itself may spread deeply. For this reason there is one important contraindication to incising the dura—namely, established sepsis in the wound If a casualty has lain out for three or four days it will be safer not

to open the dura if it is intact and to regard him as a case of potential cerebral abscess.

THE WOUND TRACK IN THE BRAIN

If good results are to be expected and no further damage done to the surrounding brain, the minutiae of the neurosurgical technique must be closely observed. The operation is planned, not to relieve say, a hemiplegia, but to extirpate as early as possible the agents which caused it. All manipulations should be carried out very gently the wound must not be packed with gauze. Suction is most useful when available Cotton wool should be used for swabbing rather than gauze though the latter is quite permissible for scalp and bone Heavy pressure or retraction on the brain not only causes further cerebral con tusion but also sets up oedema The meticulous avoidance of pressure and the careful sealing of vessels are two of the main differences between the technique of general surgery and neuro-surgery As the object in treating open injury to the brain is the prevention of infection by the removal of dead tissue, in driven bone, and foreign bodies, the importance of careful radio-logical studies before the operation is started cannot be undnly stressed The number of fragments removed should tally with the pre-operative count.

Theoretically the edge of lacerated dura mater ought to be excised because it can be presumed to be infected. Experience however has shown that not only is this unnecessary but it is inadvisable because adhesions rapidly form between the swollen cortex and dura mater these form a natural barrier against the spread of infection into the general meningeal spaces. We should see meningitis more often if the dura mater were so widely removed that access was easy from without to the leptomeningeal spaces.

If the wound has no particular depth a superficial toilet by syringing with hot saline and the extraction of bone fragments, aided by the patient s coughing or straining to cause the extrusion of debris, is all that is necessary If there is a deep track further steps must be taken. The aim will be to clear the track of foreign

blood, and the bleeding becomes uncontrollably profuse The surgeon will see to these things beforehand (including the obtaining of muscle as the first step) if a wound encroaches at any part of the surface marking of the sagittal or lateral sinsues It is wiser then not to use the block removal method, since the elevation of the fractured area may cause an unpleasant haemorrhage The bone over the laceration is better removed piecemeal by nibbling forceps until the tear is freely exposed in its whole length and on both its sides, it is useless attempting any kind of repair until this step has been accomplished The type of repair will depend, of course, on the nature of the injury If the continuity of the sinus is completely broken, each end must be encircled with fine silk thread and the ligature firmly tied Longitudinal or incomplete transverse tears may be repaired by closing the opening with grafts of muscle, hammered into thin sheets These Horsley muscle grafts are very efficacious, as they stick like postage stamps across the gap in the sinus, and of all the known methods they are the most easily applied and the most commonly used.

WOUND CLOSURE

A careful closure of the wound is essential if good results are to be expected the aponeurosis should be pulled together with buried sutures of the finest silk and the skin edges opposed with great care Catgut is a bad material for buried sutures in the scalp It can be stated with some certainty that any wound that can be drawn together purely by buried sutures is not under too great a tension so far as the skin flaps are concerned This is aided by dissecting them up widely by touches with the scalpel in the loose areolar layers between galea and peri-

EPILEPSY

Convulsive seizures of focal or generalized types may develop either within the first days of acute head injuries or late The retained missile is of no particular importance in the production of these neural explosions it is the cerebral injury that matters

When epilepsy occurs in the early stages, as it may the seizures are due to local haemorrhage or oedema, and may be controlled by intramuscular injections of luminal 3 grams or by large doses of bromide and chloral given orally or by rectal injection. Lumbar puncture should be done to see if meningitis is the cause, often it is not. The question of late epilepsy does not come within the scope of this discussion suffice it to say that it can be expected in a very large proportion of cases when the dura has been perforated and particularly when there is a cortical scar adherent to the skin. It may develop at any time after the injury and I have known it to occur for the first time twenty years later

MENINGITIS AND VENTRICULAR INFECTION

Although on theoretical grounds infection of the meninges might well spread widely from the site of a cortical wound and be a common cause of death, experience shows that it is relatively rare The meningeal spaces become sealed off by oedema of the brain around the contused area and a defensive barrier arises, partly mechanical by obliteration of dead space, partly the result of sealing of blood clot (Fig 11) When operative cleansing of the wound is undertaken reasonably early this barrier is sufficiently effective to prevent major disaster The presence of leucocytes and even polymorphonuclear cells in the cerebrospinal fluid is no indication that a fatal meningitis is established or even on the way Pleocytosis of this kind will often subside without its ever having been possible to grow organisms from the fluid. Even when there is bacterial infection death does not necessarily follow though it of course signifies a grave condition. Experience taught me that the worst examples come from a deeply extending septic encephalitis that infects the ventricle.

Once this has happened the cerebrospinal fluid circulation washes the organisms widely through the ventricular system and will carry them to the full extent of the leptomeningeal spaces The majority of these patients die The moral lies in the need for a most careful cleansing of the wound and the avoidance of any rough, and particularly any blind, procedures carried deeply into the cerebral tissues

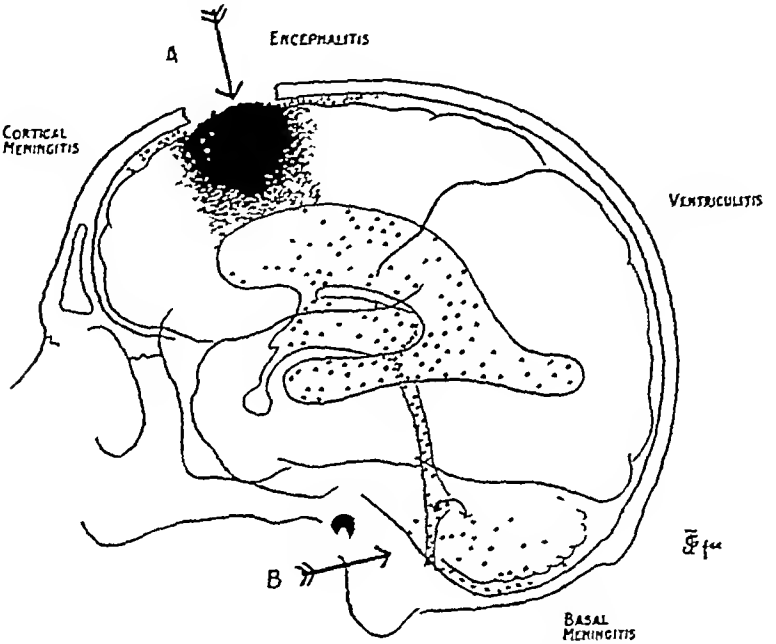

Fig 11 —Diagram of common route of infection in head wounds The local injury is sealed off by adhesions (A) Local meningitis (B) Basal meningitis, by ventricular infection escaping through the foramina of Magendie and Luschka Fig 11 is reproduced from the *British Journal of Surgery* (1919, 7, No 26), by kind permission of the editor and of the publishers

The treatment of meningitis consists in repeated lumbar punctures (two or more daily) or continuous lumbar drainage by keeping the needle *in situ* for two, three, or more hours, aided by chemotherapy. The last is the most important of all

CEREBRAL FUNGUS

If a wound does not heal by first intention, and especially if the scalp has been closed under undue tension, the edges of the wound will part in the middle and a cerebral fungus develop

the head, the positioning of the patient, and local infiltration of novocain It is a mistake to assume that the urgeney of operation is so great that all surgical ideals should be disearded There are now enough neurosurgical centres, and teehnique is so standardized that all likely to have to deal with these war wounds ean obtain an introductory training which would fit them to do so

There is one last point, and that is the value of keeping the patient in the hospital where he has been operated upon for at least ten days afterwards The results are better if this can be done, not only beeause travelling upsets the patient, but ehiefly because some continuity in treatment is of the greatest importance It is naturally extremely diffieult for a fresh group of people to understand the exaet nature of a lesion hidden beneath a newly sutured scalp

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THE MENTAL ASPECTS OF A R.P

By JOHN RICKMAN M.D

The mental aspects of A R P are important, because if there is panic or loss of nerve' all other A.R.P will be unavailing The more general aspect will be stated here.

Modern warfare is waged on two fronts—military and civilian (Langdon Davies, 1938) On the military front men must in the face of death work like parts of a machine their emotional life must be centred on their regiment and their every action must be shaped to continue the activity of that well recognized group of fellow men If this loyalty is enough to prevent demoralization the task of the attack is to pound the men themselves to bits physically On the civilian front, on the other hand the task of both the attack and the defence is different. The civilian population is not organized into regiments which by special training and tradition claim and inspire the self forgetful devotion of individuals. Group-feeling is divided between the family work mates, and to a varying extent the nation itself (represented by the King and by political and social institutions) Further the kind of response required of the civilian population is different from that required in the Army Business as usual Keep the home fires burning are war time slogans which have an important military significance, standing for the normality of life for which the struggle is being waged The task of the attack is to disorganize the morale of the civilian population of the enemy a thing which can be achieved by arousing so much nervous apprehension that the slogan Safety first' will be spontaneously in everybody's mind. The object of the attack must be to make the population give up trying to live a normal life or thinking of a normal day's work, the weapon is fear For the defence to be effective the population must feel that they are being well and resolutely led that their liberties are being pro-

the head, the positioning of the patient, and local infiltration of novocain. It is a mistake to assume that the urgency of operation is so great that all surgical ideals should be discarded There are now enough neurosurgical centres, and technique is so standardized that all likely to have to deal with these war wounds can obtain an introductory training which would fit them to do so

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The mental aspects of A.R.P. are important, because if there is panic or 'loss of nerve' all other A.R.P. will be unavailing. The more general aspect will be stated here.

Modern warfare is waged on two fronts—military and civilian (Langdon Davies, 1938). On the military front men must, in the face of death, work like parts of a machine; their emotional life must be centred on their regiment, and their every action must be shaped to continue the activity of that well recognized group of fellow men. If this loyalty is enough to prevent demoralisation the task of the attack is to pound the men themselves to bits physically. On the civilian front, on the other hand, the task of both the attack and the defence is different. The civilian population is not organized into regiments which, by special training and tradition, claim and inspire the self-forgetful devotion of individuals. Group-feeling is divided between the family, work-mates, and to a varying extent the nation itself (represented by the King and by political and social institutions). Further, the kind of response required of the civilian population is different from that required in the Army. "Business as usual", "Keep the home fires burning" are war-time slogans which have an important military significance, standing for the normality of life for which the struggle is being waged. The task of the attack is to disorganize the morale of the civilian population of the enemy, a thing which can be achieved by arousing so much nervous apprehension that the slogan "Safety first" will be spontaneously in everybody's mind. The object of the attack must be to make the population give up trying to live a normal life or thinking of a normal day's work; the weapon is fear. For the defence to be effective the population must feel that they are being well and resolutely led, that their liberties are being pro-

tected, and that protection from danger for individuals is fairly distributed

PANIC

The word "panic" is used loosely to describe a number of conditions, it may be defined as a condition in which the individual experiences the highest degree of dread, in which his social ties are temporarily severed to a greater or less degree, and in which he loses self-control The degree of actual danger is not the sole causal factor, indeed, no one factor causes it A predisposition to nervous states plays a large part, there is something in the mind of the predisposed which goes out to meet the danger half-way, and thus in the imagination reinforces it In dealing with panic the difficulty is to control the imaginative or fantasy element, which is influenced by the unconscious part of the mind

The anxiety conditions associated with acute war danger found in normal people may be divided into four stages

1 *The prodromal symptoms* lasting from a matter of seconds to hours or longer, characterized by the feeling that one will not be able to maintain self-control much longer If the danger goes off, or if "moral reinforcements" turn up, this may end the manifest trouble

2. *The acute stage,* characterized by motor overactivity (occasionally paralysis) of the voluntary or involuntary muscular systems, more rarely by stupor or a wish to sleep During this stage the person may still be accessible to "moral reinforcement", the power of response to leadership is not lost, and the answer to command may be prompt It should never be assumed that because a person looks "jittery' nothing can be done to steady him Failing such reinforcement this is the stage where individuals scatter, break formation, and run from their friends and duty

3 *The chronic stage,* in which there is a diminution of motor activity and return of sphincter control, but appetite is disturbed and there is insomnia Above all, the return of "social sense" is slow, the response to command is feeble or lacking, and the individual has lost his sense of belonging to a group

4 *The stage of resolution* consists in a resumption of social con-

tact, response to command, realization of responsibility, and return of self respect. To repeat it must not be assumed that because a person is 'all jittery' nothing can be done for him, his need of help is obvious, and in many cases can be effectively met.

The effects of high explosive fortunately do not bring fundamentally new problems for the psychologist to deal with: the aetiology of this kind of neurosis is basically the same as that of the more familiar peace-time varieties (Jones, 1918). The strain of war conditions leads to the reactivation of latent neurotic conflicts which originate in infancy, and since these are literally unconscious the subject is unprepared for them and cannot control himself when faced with what is to him an intolerable danger. The aetiology and prophylaxis of panic has been discussed at some length elsewhere (Rickman, 1938), but something more must be said of the part played by 'moral reinforcements' in overcoming an attack of 'nerves'.

EFFECT OF "MORAL REINFORCEMENTS"

Though an anxiety attack in adult life may be precipitated by a present danger, the character it takes will depend not so much on the nature of the danger as on the individual's own mental make-up, which in turn is based on the way in which he managed to overcome his anxieties at a time before his character became consolidated—namely, in infancy. As an emergency therapeutic technique we may employ in the case of the adult those measures which were effective in overcoming the early anxiety attacks. What were the 'moral reinforcements' then used? Three main ones may be signed out: (*a*) manipulative activities, (*b*) work for others, and (*c*) membership of a group.

The performance of purposeful acts ('manipulative activities', Rivers, 1920) helps the individual to get command of his "nerves" and to allay his fears. The military objective of returning a man or woman to duty has therefore a therapeutic value if the individual's mental co-operation can be obtained. The co-operation is best achieved if the person can be got to feel that he is doing something for those with whom he has close ties—that is, he can make good the damage done in fantasy under the influence

of aggressive impulses. It must be remembered that panic, and anxiety states generally, are a mixture of apprehension on account of *external* danger, and of anxiety and guilt on account of *internal* unsocial and egotistic impulses—that is to say, there is a mental conflict in the unconscious part of the mind in which both tender and hostile thoughts directed to the same person are trying to find outlet This conflict produces guilt as well as anxiety, and for a proper understanding of the anxiety reaction the guilt element must be appreciated as well as the influence of the external danger. It is the guilt component which makes the return of the individual to his place in the group a difficult step (On the other hand, Authority, for its part, must show leadership and capacity to realize the needs of the people, mental as well as physical: *to govern*—that is, to keep order and dispense justice fairly; and *to protect*—that is, supply essential needs of physical and sanitary protection and provide food and distribute all impartially.)

THE SOCIAL NEED

These considerations have practical bearings The individual must be regarded not only as being a neurological entity, so to speak, but also a human creature with a strong social need His dependence on the good will of his fellows and his need to give help to them are as much a part of his mental make-up as his upright posture and developed cortex are of his physical make-up.

The strain of war conditions in the direction of disturbing morale will affect a small proportion of civilian population seriously and a larger proportion subliminally. The aggressive impulses, inevitably mobilized, do not find adequate and immediate outlet, and the individual when dealing with the increased mental tension dreads unconsciously that he will become aggressive to his friends instead of his foes He does not in these circumstances trust himself with his friends, and therefore his social bonds and his self-confidence are impaired

RESTORATION OF SELF-CONFIDENCE

The handling of the individual in the early stages of panic, and indeed the whole question of morale in a group if one of its

members "gives way", turns upon the moral reinforcements which can be mobilized. In an emergency the question is, What short cut can be taken to restore self-confidence? The physician cannot, of course rely on the patient being reasonable any more than a child in a fit of terror can be reasoned with, so he must deal with the irrational apprehensions which rob the patient of his self possession. To deal with such a situation the physician should try to discover or guess what sort of thing the patient is anxious about rather than to discourse to him about what he should do or think. Diagnosis and subsequent handling depend in a large measure on making the right guess as to the nature of the anxieties at the back of the patient's mind. Just as a child in these circumstances needs assurance, so does a panic-stricken adult: the patient desires something to make the fear less and, speaking generally, that something is a person who will seem to the patient to be stronger than the horrors which haunt him. It is not a case of making the patient invulnerable to external danger. (Physical protection is a help but to be effective must be recognized as such; fears often blur the judgment badly even on this point.) The important anti-panic measure (other than providing for physical security and an adequate outlet for the aggressive and constructive impulses of the population—which, after all, is the duty of the Government) is to eliminate fears of internal danger, or going mad, or of running amuck, and to do this the helper must appear in the patient's fantasy as a steady and kindly parent figure, a reassuring representative of a good or respected authority.

THE DOCTOR AS A MORAL REINFORCEMENT

The doctor in virtue of the role he is assigned in his patient's fantasy (as well as because of his actions) is fitted to play the part of a moral reinforcement to distracted people; but if the profession is going to take responsibility for the quieting of emotional crises it is desirable that those who are interested in this should prepare themselves in advance for this trying duty. Every qualified man knows when he is called to accident what to put in his bag, or when he gets to the scene what he can do in

the way of first aid First-aid posts are being established for physical injuries and are being equipped with appliances that experience has shown to be necessary First aid in psychotherapy does not require much in the way of outfit, but calls for every bit as much training of personnel and as much foresight in administration The knowledge that such provision is being arranged would itself be a reassurance To give only one instance of the reassuring nature of medical knowledge, it is important for doctors to know that the last war did not in fact increase the amount of insanity in the community, or in the Army If people can say that the war danger will drive men mad they can be told with truth that generally it does not have such effects In this work the medical profession will co-operate with the police (allies experienced in dealing with a distracted populace) and also with the air wardens These enthusiastic but generally less experienced men will need the help of doctors, who will sooner or later have to take over responsibility for teaching the psychological as well as the physical first aid

SUMMARY

The mental aspects of A R P cover a wide field—namely, the morale of the population and the reasons for the breakdown of morale in the individual The progress made in the field of mental pathology since the last war should enable us, by a deeper understanding of the role of anxiety and guilt in the mental make-up of the normal as well as the neurotic subject, to see in advance better than formerly where trouble will arise, and how to meet it The medical profession should take seriously the responsibility for training themselves and auxiliary personnel in the handling of anxiety or panic cases, and should not delay in beginning preparations

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PSYCHOLOGICAL EMERGENCIES IN WAR TIME

By MAURICE B WRIGHT, M.D

In any war with modern weapons of destruction, psychological emergencies or as they are more often called, psychiatric casualties will be much the same in character although the proportion of the different types of casualty may vary During and after the great war many books were written describing the different types of psychiatric casualties both in this and in other countries. After twenty years much of this literature has fallen into oblivion, and a generation of medical men has arisen to whom war neurosis and psychiatric casualties are largely unknown. It is only the recent political situation, with the ever present threat of war that has brought the whole subject out of the oblivion into which it was gradually dropping It is recognized by all thinking men and women, medical or lay, that the psychiatric casualties in the present war of the character we are told we must envisage, may have even more far reaching effects than physical casualties, loss of life, or material destruction. It is a problem that everyone, at any rate in our large towns is having to face—not so much, Shall I be killed or injured?' but Can I face it shall I break down shall I keep sane or normal under the conditions I may have to endure? There can be no question that many perhaps most, of us cannot feel quite sure of the answer

I think it is impossible to estimate with any certainty the number of psychiatric casualties that will have to be dealt with if any civilian population is exposed to frequent and intense aerial bombardment. During the great war psychiatric casualties occurred among disciplined troops, mainly young and to some extent at any rate selected all of them subjected to a training

which would make for the raising of morale and obedience to orders War directed against a civilian population exempts no one, excludes no one The morale of a civilian population is impossible to assess beforehand, it will depend on many factors—to a certain extent on class, to a greater extent on the density of the population exposed, and probably to the greatest extent on the adequacy of the protective measures and the confidence these measures inspire The civilian population must be treated as if they were combatant troops, they must be under authority and know what to do and what to avoid doing in case of emergency The authority also must not be remote, but, like a battalion commander, be personally known and accepted before the emergency arises

The following attempt to classify psychiatric casualties is based on experience during the last war, both personal and communicated Like all classifications, it must be to some extent arbitrary, types will not always be clear-cut, and exact diagnosis will often only be possible long after the case has left the casualty clearing station for special psychiatric hospitals The classification attempts to represent the various forms of psychiatric casualties which may be admitted to first-aid posts and casualty clearing stations, and is not meant for the skilled psychiatrist, whose services may very often not be available It will probably be useful to try to divide the admissions into the following groups. cases of simple terror, anxiety hysteria, conversion hysteria, including hysterical stupor, concussion, and psychoses

SIMPLE TERROR

It must always be remembered that terror is not in itself pathological, it is a normal biological response to stimuli which are felt, rightly or wrongly, to be a threat to life or are entirely foreign to all previous experience It is, as a rule, a short-lived reaction and passes quickly, either by getting into safer conditions or when the danger has passed In cases of simple terror the instinct of self-preservation is in action, but not to such an extent that habituation to dangerous conditions is impossible, and, as the terror passes, purposive action in the interest of the group is again possible.

It has been said that during a raid first-aid posts and casualty clearing stations will be filled with terror-stricken people I think this is doubtful most of those in a state of simple terror will stay where they are or go where they feel safer and a great majority will overcome the terror and if they have a job to do will carry on

How can we differentiate the real coward? The real coward is a coward always and all the time—in situations of danger the instinct of self preservation is always uppermost he will see to it beforehand that he can go at once to safety and nothing will move him he is not always overtly terrified To quote what has often been said, The brave man is afraid of being afraid the coward is afraid of being brave.

ANXIETY HYSTERIA

In peace time the label anxiety hysteria is given to by far the greatest majority of neurotic maladjustments and illnesses and includes a very great variety of psychological as well as somatic disturbances which are found to be related to anxiety and the anxiety is in perhaps most cases conditioned not so much by external conditions as by internal conflicts. As a psychological emergency in war the anxiety hysteria will resemble the severer forms of anxiety attack seen occasionally in peace time, but will, at any rate, apparently be more definitely related to the dangerous situation, whether past present, or anticipated.

It will be important to try to differentiate the real anxiety hysteria from the attack of simple terror It will not always be easy but there is one difference which although it is not invariably true is of fairly general application In the anxiety hysteria the emotional response to the situation has ceased to be biological and therefore to some extent useful, but has become pathological. The instinct of self preservation has often ceased to operate flight, or any purposive action of effort of will to overcome the terror has become impossible. The emotional upheaval is so great and the somatic accompaniments of fear are so intense that no amount of reassurance, or removal to a place of safety no appeal to any ego ideal of courage, elicits any response for the time being The individual has regressed to a more

primitive level, the effect of fear on the whole autonomic system has for the time being put out of action the higher centres of volitional control.

Severe cases of anxiety hysteria will not come themselves to the casualty clearing station or first-aid post, they will be brought there, often as stretcher cases, during raids or shortly after, they may be brought in from the streets or air raid shelters, collapsed and tremulous, or wandering in a purposeless way with clouded consciousness or even amnesia, near to any severe explosion, they may be found lying apparently unconscious in the state of hysterical coma or stupor which will be referred to later Between raids they will be brought to hospitals by their relatives, perhaps from homes close to a bombed area or from districts quite untouched—perhaps not such severe cases as those occurring actually during a raid, but quite impossible to nurse at home There is a constant expression of terror, a coarse tremor, sweating, and tachycardia, they scream sometimes if touched, and some lie curled up under the bedclothes in the intra-uterine position These are the severer psychiatric casualties which will most certainly occur in bombed areas They may recover fairly quickly from their acute symptoms under hospital conditions, but evacuation is imperative, not only for the individual but because, if these cases are sent home, they will certainly relapse and become sources of "infection" to those around them who may be themselves on the verge of breakdown I believe it to be most important to realize that many milder cases of anxiety hysteria may need to be evacuated, not so much for the sake of the individual as for the community, who may be infected by their anxiety and themselves become less tolerant of stress

CONVERSION HYSTERIA

It may be wise even nowadays to restate what it is that is converted in conversion hysteria It is anxiety that is unconsciously converted into some disturbance or even complete inhibition of a somatic function This is true, and always true, not only of war conversion hysteria when the anxiety converted is the result of terrifying external situations, but also in the conversion

hysteria of peace time when the anxiety is more often of endopsychic origin. The conversion hysterias are modes of dealing with and often completely inhibiting anxiety The hysterical pareses mutism, asphasia, deafness blindness—all are the result of acute anxiety but converted into the somatic disturbances and no longer felt as such. The hysterical paraplegic, the aphasic, the deaf—all of these have ceased to be anxious about the original traumatic experience and even any anxiety about the actual symptoms seems often non-existent. It is the same mechanism in the hysterical fugues amnesias, and stupors many of which may be seen as psychiatric casualties

Much has been written about what is called the period of latency the interval that often elapses between the initial shock or production of acute anxiety and the development of conversion symptoms. It has been called the period of subconscious elaboration, or, by some French writers the period of rumination From some of these writers one gets the impression that they consider that in the period of rumination there is a sort of conscious attempt to avoid the anxiety by means of conversion. I do not believe this is true, the conversion symptom is not consciously willed, and whatever happens in the latency period is carried out not in the field of consciousness but at deeper unconscious or preconscious levels Nothing is known definitely about what does occur or how the conversion is made we may speculate but certainly in my opinion, we do not know

Conversion hysterias are true dissociations of consciousness, the hysteric has no awareness of the function which is lost, whether it is speech or some part of memory or motility It is perhaps related to this that so many cases of conversion hysteria in war time are initiated sometimes suddenly without any latency period by any momentary loss of consciousness, such as may occur in proximity to a severe explosion or on being momentarily buried under a fall of earth or debris. There is probably no true concussion, and they do not present the symptoms of cases of true concussion. One striking fact emerged during the last war and was confirmed by all observers By far the greatest proportion of cases of conversion hysteria occurred among the

men in the ranks, comparatively few among officers There may be many reasons for this, in my own experience the true conversion hysterias often occurred among the rather naïve, simple, not very intelligent type of soldiers—often not overtly very anxious in the firing line, obeying orders, accepting authority, but avoiding any *responsibility*. When they broke down they did so suddenly after only a short period of acute anxiety, or after some experience of intolerable stress Through this conversion symptom they obtained not only relief of intolerable anxiety but sanction for removal from the danger zone, which would persist so long as the symptoms remained

It is as if the officer, with his training, his sense of responsibility, his higher ego ideal, could and did tolerate enormous amounts of anxiety before the final breakdown, but, because of his ego ideal, could not sanction the complete flight of the conversion hysteric The man in the ranks of the type described, with no ego ideal, no sense of responsibility to anyone but himself, had nothing to inhibit the mechanism of conversion, whatever it is, which gave him so complete an escape These views are admittedly only superficial explanations, and many other psychological determinants which would explain the difference between the two groups would emerge during treatment.

HYSTERICAL STUPOR

There is one form of hysteria that was seen fairly often during the last war and may, I think, be seen much more frequently in a future war when the brunt of the attack may be upon human material of all and every type without any selection either for mental or physical fitness, this is hysterical stupor or coma It is important because it is not always easy to distinguish between hysterical coma and severe concussion, and the treatment and subsequent history are entirely different These patients will be found lying apparently deeply asleep or unconscious I use the term "asleep" advisedly, because French writers in the past have called the state "narcolepsy", although it is entirely different from the narcolepsy of modern neurology They will generally be found somewhere near to a bombed area, generally flaccid but

with no disturbance of the deep reflexes. If an attempt is made to open the eyes it is resisted by strong contraction of the orbicularis. The eyeballs are turned strongly upwards and fixed. There is sometimes, but not always, relaxation of sphincters. They may remain like this for hours or days and then recover, often with a patchy but not complete amnesia both anterograde and retrograde From the nursing point of view these cases are in my personal experience often most difficult and very alarming The patients will sometimes recover consciousness quite suddenly and become very violent and uncontrolled, attacking, or more often pretending to attack, those who come near them then after a violent period they relapse again into coma. The attack resembles closely the somnambulisms, often intensely dramatic and alarming, which occur very frequently among anxiety hysterics in war times when in hospital.

OTHER DISTURBANCES

The conversion hysterias that have generally the most definite, and often long, latency period are the paraplegias. They will frequently occur associated with a slight wound or injury but quite unrelated to the extent or even situation of the injury They will vary endlessly in character—complete paraplegias, disturbance of gait with or without contracture, monoplegia of the arm with *main en griffe* or accoucheur hand. There will be endless cases of coarse tremor often resembling an intention tremor and confined to one limb, or spreading to every limb when any movement is suggested. There will be tics of all kinds and many stammerers. These last two forms are nearer akin to the anxiety hysterics, and all the anxiety will not have been converted. Another group will be the so-called psychosomatic types—cardiac neuroses, respiratory neuroses, and visceral neuroses. I have seen persistent attacks of severe orthopnoea in cases which occurred through being buried. In this last group anxiety is still felt, but has shifted from the original emotional trauma to anxiety about the function that is disturbed.

Hysterical amnesias will be fairly often seen as psychiatric casualties, and must be differentiated from post-concussion

amnesias—not always very easy, especially if there is a history of proximity to a severe explosion with the possibility of a momentary true loss of consciousness They are frequently very patchy, both retrograde and anterograde, and in the patchy amnesias there is often still some anxiety and some confusion The man remembers nothing since, for example, he was in a training camp in England, but feels that something dreadful happened after this Other rare cases are complete amnesias for all the past One patient I remember very well was exactly like a child, but with no memory of his parents or home, until he recovered he had to be taught again how to feed himself, to read, and to write The true hysterical fugues—the cases where men are found wandering with a complete retrograde amnesia, going back either for days or months—are not, in my experience, so common A fugue is so often the easiest form of true malingering and not always the easiest to detect I have myself worked at a fugue case for many months in a very intelligent man of the officer class, only to find out in the end that he was a true malingerer with no loss of memory at all. Others are quite easy to detect after a little questioning, and are often associated with the end of leave. True fugues do exist, of course, but they are much easier to simulate than the patchy amnesias associated with more or less anxiety.

CONCUSSION

Here we are on debatable ground Cases of true concussion may be considered as neurological rather than psychological casualties; but they will certainly often be regarded as psychiatric casualties, because they will be found unconscious without any sign of physical injury. It is also debatable ground because in much of the literature on war neuroses cases are included under concussion when, although there may have been transient loss of consciousness, there are marked symptoms of anxiety hysteria, or even of conversion, immediately or shortly after the traumatic episode

In true concussion the period of unconsciousness may be extremely short, or deep and prolonged In the slighter forms

the man may recover and carry on with what he was doing, apparently little the worse. In all cases, however of true concussion I believe there is one significant feature—a retrograde amnesia which, short or long is always clear-cut and definite, and an amnesia which is permanent, there may also be a varying anterograde amnesia not so clear-cut as it emerges into full consciousness, but also permanent Concussion patients as they recover may be confused often for a long period, but there is not the same amount of anxiety as in the hysterical cases the complete retrograde amnesia has also cut out all recollection of any anxiety or emotion felt just before the traumatic incident. All the concussion cases are, in my experience, more serious than the anxiety hysterics, in severe cases the ultimate prognosis is very uncertain and some deteriorate into a permanent condition of mental hebetude and depression A severe case of concussion brought in unconscious should be fairly easily differentiated from hysterical stupor The patient is profoundly unconscious, deep reflexes are abolished muscles are hypotonic, pupils are often unequal and there may be ophthalmoplegia or ptosis

THE PSYCHOSES

In any civilian population there are a fairly large number of psychopathic personalities mild manic-depressives, schizophrenics in remission, and superior mental defectives All of these will stand the strain of war conditions badly and will become psychiatric casualties. In the last war cases of katatonic stupor were found in casualty clearing stations mildly depressed men became acutely maniacal cases of mild hypomania became acutely depressed. The problem of the effect of war on high grade defectives is in war time often more a social than a medical problem. In the last war some of this type managed or were compelled to enlist, even obtained commissions. Many drifted into military prisons or were sent into special hospitals for observation and report for various delinquencies, character disorders, or anti-social acts. There will probably be more of these in any war on civilian populations.

I have said nothing about the effect of war conditions on the

obsessional neurotic, of whom there are very many. I have done this deliberately because, in my opinion, the true obsessional stands war conditions as well as or better than most, when he does break down he will become for the time being an acute hysteric with similar symptoms It will only be when under treatment that the obsessional character will again emerge and present a definite problem

Neither have I said anything about the more specific effects on women and children, here much could be written, but it must be, and I hope may remain, speculative

I have given a classification in which any psychiatrist, including myself, could pick as many holes as are in a sieve I have only attempted one which may have some practical value

TREATMENT OF PSYCHOLOGICAL CASUALTIES DURING WAR

By MAURICE B WRIGHT M.D

Before considering the treatment of individual psychiatric casualties there is first of all the much bigger question of policy What policy will be adopted with regard to the position of the hospitals for these casualties, either within or fairly close to the danger zone, or further away and immune from attack? Will patients as a matter of policy not emergency be sent to their homes as soon as the symptoms of anxiety hysteria have been relieved or the conversion hysteria cured for the time being by whatever method or will all except the very mildest cases be given the chance of complete rehabilitation before being sent back either to civilian life or to their unit in the combatant services? In a severely raided civilian population, where psychiatric casualties are certain to be heavy mere pressure on bed space either inside or without the danger zone may make it impossible to keep any but the severest casualties in hospital. Apart from necessity however two more or less opposite opinions are held by psychiatrists of experience One point of view is largely that of psychiatrists who had experience in the last war in France or other fronts the other is held mainly by those whose main experience at any rate was in special hospitals for psychiatric casualties at home

CHOICE OF TREATMENT

The first group hold from their experience that psychiatric casualties should be treated in hospitals within the battle area They should be treated by any methods to be discussed later which would render them more or less symptom free, and then returned to their unit. The second group to which I myself

belong, would hold that there were very frequent relapses among those treated by rapid methods, and that relapsing cases were much harder to deal with than those evacuated on their first breakdown They would hold that among those sent back too soon there was a not negligible danger of suicide, wounding by deliberate exposure to enemy fire, or of self-inflicted injury, they would believe, too, that no case of anxiety or conversion hysteria can be fully rehabilitated in a matter of days. The most serious criticism would be that, according to all modern psychotherapeutic theory, methods of treatment which stress the removal of symptoms rather than treatment of causal factors may have utilitarian value but do not make for permanent cure

Let me say at once that I quite realize the practical value of the first method during the last war, which was waged between combatant troops and not directed mainly against the civil population These methods did return a good number quickly to their units, and certainly some of them remained stable, but they remained stable for a certain definite reason They were treated by methods which I should like to call the methods of authority, and they were returned to authority, they could accept it and find value in the discipline, the morale, and camaraderie of their unit They very possibly had a period in rest camp for further readjustment For them their unit was just as good as, or perhaps better than, a hospital for regaining morale The point I want to emphasize most strongly, because I believe it to be the crux of the matter, is that the situation is entirely different when we are dealing with psychiatric casualties in a civilian population. If they are treated by authoritarian methods and sent as quickly as possible to their own homes they will be removed from authority to where there is no authority to help them They would return to homes possibly in a bombed area to a family which, even if still intact, would probably be badly shaken Only a large body of social workers could find out whether they would return to conditions where there was any possibility of restoration of morale.

USE OF AUTHORITARIAN METHODS

I must now define what I mean by authoritarian methods. Let us start with the French method as described by Lhermitte He insists first of all that the physician must be a man of strong will, that he must have the iron hand in the velvet glove, the patient must at all costs be mastered. If what he calls psychological conversations did not relieve symptoms the patient was isolated in a single room, given a diet of milk and bread, or later of bread and water if the symptoms still remained. If he relapsed he was returned to rigorous confinement. He was also kept in confinement if he refused treatment by faradization, which can be, and was in my personal experience a very exquisite form of torture. Treatment by hypnotic suggestion, persuasion and re-education, although not so punitive as the French method appears to have been, is if only directed against the symptoms, an authoritarian method. The physician stands for the stern or kindly parental authority who with the patient either in the hypnotic state or in full consciousness, insists that the symptom, whatever it is, be given up It may be given up or as is so often the case, changed over to another symptom, but without any true insight into the meaning of the latter Treatment by hypnotism with abreaction of affect—that is, the revival of traumatic memories in hypnosis—undoubtedly produced dramatic relief of symptoms in many cases but it is doubtful whether the patient gains any true insight by this method, and I have certainly seen cases where the abreaction was so violent and disturbing that further treatment would not be accepted. There is one definite danger in the use of any authoritarian method in a fairly large group of cases—they may become rebels against authority and if they relapse are much harder to treat.

All forms of psychotherapy depend to some extent upon authority All psychiatrists know that at some time or other during treatment they may come to stand for father or mother to the patient. But there is all the difference between the parent who just forbids and says Don t ' and the parent who is trying all the time not to forbid but to explain.

During the last war in the special hospitals for psychiatric casualties authoritarian methods of some sort were used in varying degrees. In some, authority was much too strict, in others, very definitely there was too little It must be remembered that at that time there were very few trained psychotherapists or psychologically-minded physicians, and these were generally overworked and overloaded by details of administration Towards the end of the war, when officers had been trained at Magull in the psychological approach, conditions did improve and better work was done It can be hoped, I believe, that conditions in any future war will be better, there will still be a shortage of trained psychiatrists, but it will not be so acute, and the whole attitude of the profession and the laity towards the genuine psychological approach to the problem of the neuroses has been revolutionized to a large extent There will be one great difficulty in the treatment of civilian casualties—the lack of authority Patients will be free agents, and many will clamour to go home before they are fit to go.

TREATMENT OF PSYCHIATRIC CASUALTIES

To come now to a brief consideration of what can be done for psychiatric casualties, I shall refer only to the treatment of cases of anxiety and conversion hysteria At the first-aid post probably very little can be done Cases of simple terror should be allowed to sit quiet in some place of reasonable safety, they should be reassured and their ego ideal restored, not by urging them to be brave, but by pointing out that their fear is only natural and normal and will pass quickly because their self-control has only temporarily been weakened, a hot drink of coffee, perhaps a very mild sedative, and I believe most of them will leave of their own volition

Anxiety hysterics will arrive of every grade of severity—the screaming uncontrolled hysteric, the mute and terror-stricken with some confusion or amnesia They will come in mostly, I think, as stretcher cases, or, if walking, will be brought in by others, volitional control having gone The severer cases must be evacuated as soon as possible to casualty clearing stations,

an adequate dose of sedative should be given—I believe a big dose of one of the barbiturates is better than morphine for anxiety hysteria. Paraldehyde per rectum would also be valuable. Cases of hysterical stupor must, of course, be evacuated, and I think no attempt should be made to rouse them until they have reached the casualty clearing station and adequate nursing is available. Cases of conversion hysteria may come in especially from places near to a serious explosion. Those patients who are seen within an hour or two and with no latency period may possibly have their function restored by prompt persuasion and suggestion, but even if this is possible I believe they should also be evacuated because of the danger of subsequent acute anxiety or relapse.

At the casualty clearing hospital the amount that can be done must depend on the policy advocated and pressure on beds. It has been suggested that psychiatric casualties may remain at the larger casualty clearing stations for a period of days or weeks in the hope that they may recover sufficiently to be sent home. It has also been suggested that there will be at any rate a visiting psychiatrist to advise on selection and diagnosis. Treatment must, however, remain mainly on the lines of physical medicine—rest, whatever quiet is possible, isolation in severe cases because of the real danger of contagion, sedatives. From experience of very severe hysteria in peace time I believe prolonged narcosis may be valuable if adequate nursing is available, and evipan narcosis with suggestion given during return to consciousness. At both first-aid posts and casualty clearing stations any serious attempt at psychotherapy will probably be impossible.

TREATMENT AT SPECIAL HOSPITALS

We now come to the question of treatment at special hospitals for psychiatric casualties. The problem of the organization and management of these hospitals, many of which will be entirely for civilian casualties, will be a very difficult one. They will be entirely different from any special hospital during the war. They will presumably be large, admitting both sexes and peoples of all ages, of all types, classes, and even races, if areas of maximum

density of population are heavily bombed Also, as mentioned before, it will be impossible to maintain the same discipline and authority as in a military hospital It will be extremely difficult to establish the right sort of atmosphere for good psychotherapy It must always be remembered that every psychoneurotic is ill in mind and not in body, whatever his symptoms, and yet retains freedom to continue or discontinue treatment I can foresee many, but not insurmountable, difficulties

We will presume that in the hospital there will be a certain number of trained psychiatrists, men and women There will certainly not be an adequate number—there never will be, except in a Utopia which none of us, at any rate, will ever live to see I want now very briefly to state again what is the difference between the method of the modern psychiatrists and any method based entirely or largely on the use of authority Modern psychotherapy of every school is based on a very simple premise that all and every neurotic symptom or neurotic maladjustment is the outward and visible sign of an inward and psychological disharmony, and it is a disharmony of which the patient is to a great extent unaware The task of every psychotherapist, whatever his technique, whatever hypotheses of mental mechanism he may hold, is to try to help the patient to a solution of this disharmony, by bringing home to him the meaning of the symptoms he is made to realize that the symptom has no longer any value for any part of his personality

All who during the last war had time and opportunity to do any kind of analytical work on the war neurotics found, as we shall find again, that the anxiety hysterics and conversion hysterics had never been completely well-adjusted people They may not have been badly neurotic, but any full anamnesis, which is always the essential starting-point of all psychological treatment, will reveal some neurotic or character maladjustments—unduly anxious, unduly dependent, an over-strict and rigid code of morals and ethics which inhibited the expression of normal instinctive drive, either sex or aggression or both This is not the place to discuss different techniques of analytic approach—the aim will be the same in all All the resources of a special psychi-

atric hospital will have to be directed to one end only—the mental and physical rehabilitation of the casualty there must be carefully planned recreation and occupation and the nursing must be of the highest order for the work The nurse must be sympathetic towards the patient as a personality but not express too much sympathy about the symptoms whatever they are The nurse must be taught that most of the patients will have regressed to a level of infantile dependence they will tend to make mother figures of their nurses and they must slowly be weaned from this. It was noted in the last war that most severe anxiety hysterics became sexually impotent and yet craved the presence of their womankind. In war time I believe the psychiatrist must take his nurses if they are good into his confidence he must tell them something of the problems of the patient and get their help During the last war many nurses became invaluable helpers to the psychotherapist the opposite is unfortunately true that an unwise nurse or relative may block all his efforts.

WAR TIME DIFFERENCES

There are certain very important aspects of the psychiatric casualty in war which will differentiate them from the psychoneurotic in times of peace. One outstanding feature in a large proportion of anxiety hysterics is the constant demand for security They feel no inner sense of security or independence, and make constant demands on the outside world their family, or their group for the security they need. In a war casualty this need for security will be enormously increased and during war the outside world can offer the patient little or any of the security This intense need for security will make it extremely difficult for many cases to be returned to a world when all the bulwarks of peace-time security have been broken down Every psychoneurotic is also to a greater or less extent asocial he may make superficial contacts, but never in any real sense identifies himself with his group or community If he becomes a war casualty these asocial tendencies may be enormously increased. He may have seen all his world tumble about his ears—the loss of friends and relatives, as well as material losses. His world has never offered

him much, but now offers him nothing at all He may sink into complete apathy, from which it will be very difficult to rouse him It will need all the resources not only of a psychiatric hospital, but later of social workers and every kind of social organization, to rehabilitate these patients and make them feel the need in themselves for life in a community.

There is one other aspect of the psychiatric casualty of war which may become a very serious one, there was some evidence of this at the end of the last war and afterwards In every psychoneurotic there is maladjustment to the normal aggressive instinct The acute mental sufferings of the war casualty may release this instinct of aggression in dangerous anti-social forms He may become the complete rebel against all forms of authority and against the form of civilization which he holds responsible for his sufferings.

CONCLUSION

To sum up, at the first-aid post and casualty clearing station treatment will of necessity be on the lines of physical medicine At special hospitals treatment will be mainly psychological, combined with every other aid that can be devised towards socialization and the rebuilding of a normal ego ideal Authoritarian methods will be used again, and have a real value in many cases It is hoped, however, that the great body of experience in psychological methods gained in the last twenty years may prove its net value.

CHEMICAL WARFARE AND THE DOCTOR[1]

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From the earliest times in the history of the world certain sociological, physical, and biological factors have governed the problem of the growth of population. Disease as seen in individual cases in epidemics, or in pandemics sweeping Europe in the Middle Ages, has from time to time decimated the population. War with its horrors and vast numbers of men killed by disease and wounds, may be included in this list, together with famine, pestilence, floods, and earthquakes.

The present war, however will be different and probably more horrible. Whereas in former days war was an affair where men fought men, and women and children suffered accidentally or indirectly, to-day the idea is accepted by some Governments that it is justifiable for one nation to attempt to impose its will on another by striking a sudden swift crushing blow on vital vulnerable points in the country of its enemies. That is to say civil centres are to be attacked in addition to or apart from, definite targets of naval or military importance For this reason many conferences have been held under the auspices of the International Red Cross of Geneva since the year 1920 The problem of protecting the civil population has now been accepted by every Government in Europe, including that of Great Britain, whose A.R.P organization is so well known to all.

The subject of the medical aspects of chemical warfare is of grave practical importance to all medical men. It is not enough to be told how to treat the results of exposure to certain gases. As in typhoid, for instance a study of the aetiology pathology and clinical picture is essential. In the present paper a list of substances most likely to be met with in chemical warfare is

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given, together with an account of their physical and chemical properties and a description of their physiological action. Their pathological effects will be discussed in the next paper

HISTORY OF CHEMICAL WARFARE

A full account of the history of chemical warfare may be found in a book published in 1935 by two French naval surgeons, Héderer and Istin "Gas" is one of the most ancient devices used in fighting Details are described by Thucydides of the method employed in the Peloponnesian War, in the fifth century B.C. After months of siege, faggots impregnated with pitch and sulphur were set on fire outside the city walls The wind drove on the cloud and rendered one point of the defence untenable However, a thunderstorm broke, the rain extinguished the fire, and the first gas attack on record was unsuccessful In the same campaign an efficient "flame projector" was designed and used In 1726 Fleming described in his book, *The Perfect German Soldier*, several new poisons to be incorporated in grenades

Chemical warfare fell into disuse for the next hundred years, and the British Government refused to sanction the use of toxic shells and grenades in the Crimea. In spite of the agreement of The Hague, 1899, chemical warfare was reintroduced in the Great War and enormously developed. Although occasional use of "toxic" shells by the Germans was reported from October 1914 onwards, it was not until April 22, 1915, that chemical warfare was indulged in on a large scale The Germans launched clouds of chlorine on a six-kilometre front in a surprise attack, causing 15 000 casualties, 5,000 of them fatal. In addition large numbers of prisoners and quantities of war material were lost to the enemy. The success of this attack depended on the element of surprise No means were at hand to protect the troops Major-General C. H Foulkes, the officer in charge of the Special Brigade in France in the Great War, writing in his book, *Gas*, in 1936, states that many warnings were received of this gas attack. These were not appreciated, however, until 1932 After the April 1915 attack the matter was at once taken up by our Army Medical Service.

The first mask was immediately devised at the Royal Army Medical College Millbank This consisted of a pad of wool impregnated with sodium hyposulphite and tied over the mouth and nose by a length of veiling material Large numbers of women workers were collected and in three days the troops at the front were provided with 100 000 masks In September of the same year chlorine was used by our troops at the beginning of the Battle of Loos. The attack was not very successful and I remember seeing our own men admitted to a casualty clearing station later in the day with pink eyes and green buttons Intensive work was carried out in the perfection of the anti gas respirator until finally an article was produced which was proof against all gases except carbon monoxide and which permitted free action in fighting In 1917 the Germans first used mustard gas "—another surprise

It is interesting to note that with the provision of respirators, introduction of gas discipline and dissemination of a knowledge of chemical warfare the casualties progressively diminished although the number of our troops in the field was enormously increased

AGENTS USED IN CHEMICAL WARFARE

The most useful and generally accepted classification of war "gases" is the physiological one determined by the action of these chemical substances in various parts of the body The main groups are in the order of their toxicity (I) lacrimators (tear gas), (II) sternutators (nose irritants) (III) vesicants (blistering) (IV) lung irritants, (V) paralysants (VI) gases met with accidentally as carbon monoxide

The following list is compiled from Vedder (1925 U.S.A) with up-to-date additions

I *Lacrimators*—Acrolein benzyl bromide bromacetone bromobenzyl cyanide (B B C) chloro-acetophenone (C.A.P) dibrom methyl-ethyl ketone ethyl iodoacetate (K.S.K.) methyl-chlorsulphonate monobrom methyl-ethyl ketone xylyl bromide

II. *Sternutators*—Diphenylchlorarsine (D.A.)—Clark I diphenylcyanarsine (D C)—Clark II diphenylarsine-chlorarsine

(D M.)—Adamsite (or chloro-dihydro-phenarsazine), ethyl-dichlorarsine, *N* ethyl-carbazol.

III *Vesicants*—Lewisite—chlorovinyl-dichlorarsine, mustard—dichlordiethyl sulphide (thiodiglycol chloride)

IV *Lung Irritants.*—Chlorine, chloromethyl-chloroformate (palite), chloropicrin, cyanogen bromide, dichlormethyl ether, phenyl carbylamine chloride, phosgene, stannic chloride, trichlormethyl-chloroformate (diphosgene or superpalite)

V. *Paralysants*—Hydrocyanic acid, sulphuretted hydrogen

VI Gases met with accidentally—see Group III below

In the *Medical Manual of Chemical Warfare* (H M Stationery Office, 1939) the following classification is suggested, with a view to combining both tactical object and physiological effect

Group I—Lethal (*a*) vesicants, (*b*) lung irritants, (*c*) paralysants.

Group II—Harassing (*a*) lacrimators, (*b*) sensory irritants

Group III—Accidental (gases not used as weapons, as carbon monoxide)

The physical and chemical properties of the chemical agents most likely to be met with are briefly described below The volatility of these substances is important Gases may be persistent or non-persistent

LACRIMATORS

Bromobenzyl cyanide (B B C) (discovered in 1881), as commercially prepared, is a heavy, oily, dark brown liquid, very persistent, so that contaminated earth causes lacrimation after thirty days' exposure B B C corrodes metals except lead, it is expensive, and not likely to be used

Chloro-acetophenone [illegible] 887) consists of [illegible] stals melting at about 60° C [illegible] a high boiling [illegible] a low vapour pressure It is [illegible] y soluble in [illegible] oluble in ether, alcohol, or [illegible] a hot aq [illegible] ion of sodium carbonate It [illegible] p scented [illegible] cheap and easy to manufactu [illegible] in shells or [illegible] that it is the substance most lil [illegible] with I [illegible] istent It may irritate and red [illegible]

Ethyl iodoacetate (K.S.K.) is a dark brown liquid, invisible in the gaseous state. It is persistent and has a pear-drop smell.

STERNUTATORS (ALL NON PERSISTENT)

These substances form the irritant smokes and contain arsenic.

Diphenylchlorarsine (D.A.) (Clark I) (1878) is a thick semi solid compound, slightly soluble in water but soluble in chloropicrin and phosgene. As a vapour it is a strong irritant, and when diluted is aromatic.

Diphenylarsine-chlorarsine (Adamsite) (1918) is similar but is not soluble in phosgene. It tarnishes metals (D.A. does not) is easier to manufacture and the toxic effects last longer.

These arsenic compounds are employed as mists or clouds. Both Groups I and II are easy to detect.

VESICANTS

Lewisite (chlorovinyl-dichlorarsine) first made in America in 1918 and not hitherto used in warfare is a heavy oily liquid darkening on standing. It is easier to detect than mustard which in low concentrations may produce its effects before its presence is realized. The slight odour of lewisite resembles geraniums. It is soluble in oils, benzene, and the ordinary organic solvents. It is insoluble in water but hydrolyses rapidly. This action is increased by heat and alkalis. The blistering concentration is given as 0·334 mg. per litre which theoretically makes it an effective war gas. However as it is so rapidly destroyed by water or aqueous vapour and has not yet been put to a practical test, it is unlikely to be used in war. Lewisite is persistent, but less so than mustard.

Mustard (dichlorodiethyl sulphide) was first used by the Germans in 1917 and manufacture of this substance by us was not completed until almost the end of the war. As in the case of chlorine, our Intelligence Service secured early information the full meaning of which was however only understood at a later date. Mustard is a heavy oily liquid in the pure state colourless and almost odourless. In quantities as produced commercially

it is dark in colour and smells of mustard or garlic It is highly persistent, and stable at ordinary temperatures Heat causes decomposition into HCl and highly toxic lacrimators Contact with water causes slow hydrolysis, which is hastened by heat The resulting products are harmless—dilute HCl and thiodiglycol Since its specific gravity is 1280 at 15° C, it readily sinks when added to water Weathering will thus ultimately destroy mustard Hypochlorites react violently with mustard, producing a non-toxic sulphoxide. This explains the use of "bleach" calcium hypochlorite

Mustard is soluble in water to less than 1 per cent, but is freely soluble in the hydrocarbon oils, such as paraffin or petrol, and substances such as animal fats, ether, benzene, alcohol, acetone, carbon disulphide etc It is also readily dissolved in rubber, and permeates clothing, leather, wood, bricks, etc, like ink on blotting-paper This property of penetration into most materials other than metals and substances with a glazed surface renders its destruction especially difficult Mustard has a low vapour pressure, which explains why it vaporizes so slowly and is so persistent, and also the varying effects according to the temperature and humidity of the atmosphere

This is the gas most to be expected in war. Of 36,965 gas casualties in the American Army, 27,711 were due to mustard (Vedder), and of the 160,970 gas casualties admitted to the casualty clearing stations of the B E F 77 7 per cent were due to the same cause. Exposure to a concentration of 1 in 1,000,000 is effective

LUNG IRRITANTS

Chlorine is a greenish gas, 2 5 times as heavy as air, it therefore clings to the ground and fills hollows It is easily liquefied, one litre of liquid chlorine at 25° C will produce 434 litres of gas Its pungent smell is well known It is non-persistent Pure dry chlorine will not corrode steel.

Phosgene ($COCl_2$, C G., carbonyl chloride or carbon oxychloride) is the most effective and lethal of the pulmonary irritants, but fortunately is completely resisted by the respirator. It is a liquid, boiling at 8 2° C (46 8° F.) It is colourless, smells

of 'musty hay' and is 3·5 times as dense as air. It is non-persistent, and is easily moved on by the wind. Phosgene is readily hydrolysed so that it cannot be employed in damp or rainy weather. The hydrochloric acid liberated in the presence of moisture corrodes steel, damages clothing, and destroys the tissues of the lungs. Soda lime is used in the canister of the respirator to absorb phosgene. Phosgene will dissolve several of the toxic gases, and mixtures of mustard, chloropicrin and the arsenic smokes may be expected. This gas is liquefied easily as in the case of chlorine. *Di-phosgene* (perstoff, superpalite, or trichloromethyl-Chloroformate) is an oily liquid boiling at 128° C. It is heavier than phosgene, has the same toxicity, and is an intense lacrimator.

Chloropicrin (P.S.)—nitrochloroform—is a colourless volatile liquid, not hydrolysed by water, and semi-persistent. It also is a lacrimator. It is heavier than water, boils at 112° C., and is approximately 5·5 times heavier than air. It is killed by a solution of sodium sulphite in 50 per cent. alcohol. It has a penetrating odour and is strongly irritant. Exposure to frequent low concentrations may induce attacks of asthma.

Paralysants—These substances are not of much practical use in warfare.

Carbon Monoxide.—The management of carbon monoxide poisoning will not be dealt with in this paper.

GAS DETECTION TABLE

The following simple hints have been already published (*Pocket Book of First Aid in Accidents and Air Raids*, second edition, 1939, G. Gill and Son).

Part of Body Affected	Appearance	Smell	Chief Action	Gas
Eyes and nose	Vapour	Pungent	Tears	Lacrimator
Nose and throat	Mist	Faintly fruity	Sneezing	Sternutator
Lungs	Colourless	Musty hay	Cough	Phosgene
"	Green cloud	Pungent	Delayed collapse	Chlorine
Skin	Oily liquid	Garlic	Blisters	Mustard
	Vapour nil	Geraniums	Redness and blisters	Lewisite

CHEMICAL ANALYSIS

In the issue No 10 of volume 56 of *Chemistry and Industry*, published in 1937, appears a very important seven-page paper on analysis for the detection of poison gases by Studinger and Muller, translated by Mr F G Crosse, F.I C , from an article in "Mitteilungen aus dem Gebiete der Lebensmitteluntersuchung und Hygiene", 1936 Some of the items of chief interest are described in the following paragraphs

Preparation of the Sample

Visible drops are soaked up in filter papers held in forceps or ether extracts are made from contaminated soil All operations are carried out in a fume cupboard, the operator wearing a respirator if necessary Phosgene is detected by the reagent mentioned in C I below

Preliminary Tests

(1) Using small test-tubes, the boiling point is detected (2) Decomposibility in water a capillary loop of the extract is heated with about 0 5 c cm of water and tested with a 5 per cent solution of $AgNO_3$ Mustard decomposes slowly, chloropicrin and the arsines do not decompose (3) Tests for halogens in aliphatic compounds or in the side chain of the aromatic poison gases (4) Pringsheim's test a mercuric chloride test paper is coloured yellow by AsH_3 (5) Testing for nitrogen and sulphur (*a*) the Prussian-blue test, (*b*) sodium nitroprusside—2 drops of 10 per cent solution are added to the substance under test after being heated with sodium, a violet coloration indicating sulphide (mustard)

From tests 4 and 5 poison gases can be classified

C I —Gases resembling chlorine only xylylene bromide, chloro-acetophenone, palite (chlorine-phosgene)

C II —Gases containing chlorine and sulphur Mustard

C III —Gases containing chlorine and nitrogen Chloropicrin (HCN).

C.IV —Gases containing chlorine and arsenic. The arsines and lewisite

C V —Gases containing metal. Iron carbonyl lead tetra alkyls

Special Reactions

Halogen Test —Xylylene bromide boiled with alkaline potassium permanganate solution forms phthalic acid. This is isolated by extraction with sulphuric ether The residue is heated to 250° C with concentrated H_2SO_4 and a little resorcinol. Excess of soda lye gives a green fluorescence

Chloro-acetophenone (C.A.P)—A long test, where the substance is oxidized to benzoic acid with chromic acid then nitrated and treated with ammonia and hydroxylamine HCl solution. The presence of ammonium diamino-benzoate is shown by a red brown coloration on immersing the tube in hot water

Phosgene is detected as diphenylurea or by a colour test paper Air is passed over the sample into an absorption flask containing anil water an immediate white turbidity is produced. This is filtered off dried at 70° C and its melting point determined (235° C) Two tests are given with prepared test papers In the second test a green coloration indicates phosgene The reagents required are (1) 0·05 to 1 gramme 6-nitroso-dimethyl aminophenol dissolved in 50 c.cm of hot xylene (2) 0·25 gramme *m*-diethylaminophenol dissolved in 50 c cm of hot xylene. 5 c cm. of solution No 1 are mixed with 1 to 2 c cm. of solution No 2 and put on to filter paper This paper when held in the air above the sample turns green.

Chlorine.—One gramme of soluble starch is dissolved in 100 c.cm. of water containing 5 grammes cadmium iodide and 5 grammes sodium acetate. A filter paper moistened with the solution goes blue when chlorine is present.

Mustard —Eleven tests are given all but one requiring the presence of liquid mustard Of these the simplest is the sodium iodoplatinate test paper 2 per cent solution This paper in the presence of mustard or an aqueous mixture of it becomes purple-red then blue In this country yellow detector disks are provided which become red in the presence of liquid mustard.

Gas attacks on the civil population will be made from the air Mitchener and Cowell in their *Medical Organization in Air Raids* 1939 quote General Golovine who gives statistics showing that the complete overwhelming of a capital city by gas is impossible Repeated attacks may be made by small formations of three to nine machines or larger numbers—twenty-seven to thirty-six As the air defence of this country becomes stronger this menace is proportionately diminishing It is possible for gas to be sprayed by a low flying machine or clouds to be laid at a height The spray from the former may be seen coming from the machine and falls like rain from the latter the mist may arrive from some distance its presence being only appreciated from its effects.

For the success of a gas attack weather conditions must be favourable Clear mild still nights, with an absence of mist or rain afford the best chances for success both for non persistent and persistent gases Heavy rain and a high wind will minimize the toxic effects Clear sunny days cause rapid dissipation of the non persistent gases a raised ground temperature increases the volatilization of the persistent gases and gives rise to a high local concentration

COUNTERACTION OF GAS ATTACKS

The object of any gas raids undertaken against the civil population will be to inspire panic confusion and terror with such a lowering of national morale that peace will be insisted on at any price The air menace may be averted in four ways (1) Reliance on agreements pacts and action by such bodies as the League of Nations (2) active defence by the provision of a powerful Air Force (3) passive defence—anti aircraft units, batteries, searchlights etc (4) air raid precautions No 1 needs no comment. The second and third are becoming stronger every day in this country With regard to air raid precautions the Government's plans are gradually being perfected But further organization and liaison between various departments provision and training of more personnel, and repeated exercises and practice are required to render this arm of defence as efficient as the second and third.

The doctor not a member of the medical branch of the fighting forces will help in A R P. work. It has already been realized by the Home Office, Ministry of Health, and the British Medical Association what an important part the medical practitioner can play, whether surgeon, physician, or family doctor. He can help not only in preserving the calmness of the public, and preventing the effects of chemical warfare by correct prophylaxis, but also, by his knowledge of both first aid and treatment of the effects of gas, he can save life and hasten recovery.

It is essential that the whole nation be made gas-conscious This applies not only to members of the A.R.P. services, including all medical personnel, but also to all members of the public Refugee and evacuation camps may be attacked by gas as well as the densely packed centres of the cities Further instruction is needed, and a stricter gas discipline, with frequent respirator practice, is urged. Details of protection by sealed rooms, protective clothing of different types, and the wearing of one of the three types of respirator are to be found in the Home Office Manuals Dressing stations, first-aid posts, and operating theatres in vulnerable areas should not only be splinter-proofed but gas-proofed.

All doctors are advised to practise wearing an anti-gas respirator Familiarity with the general service type will ensure the comfortable wearing of the civilian duty and civilian anti-gas types Details may be obtained from the books, but actual frequent practice is essential The doctor should be able to get his respirator on in ten seconds or less and wear it for at least one hour, even with spectacles on, without the eyepieces dimming or any loss of technical efficiency One can lecture for forty minutes on the respirator alone without repeating oneself.

It is quite feasible to perform s[illegible] rations wearing a general service respirator, even w[illegible] son has to [illegible] glasses Wearing the haversack at[illegible] ad of the [illegible] of the chest ensures a sufficient sup[illegible] wearing [illegible] clothing Theatre sisters should [illegible] wear eit[illegible] civilian [illegible] ator, or, better, [illegible] slung [illegible]

cloud may be almost invisible There is a latent period and some minutes elapse before symptoms appear. Thus symptoms may arise or become worse after putting on a respirator, an untrained person tends to take off his respirator, thinking he is no longer being protected This is in direct contrast to Group I, where symptoms are immediately relieved by putting on the respirator The symptoms are those of severe pain in the nose and sinuses, with repeated sneezing, burning of the throat, sore eyes, aching gums, and possibly nausea or vomiting Mental distress may be a prominent feature, and inability to think or concentrate is generally experienced Although alarming, the symptoms generally disappear in an hour No permanent damage is done, and these cases need not be admitted to hospital Modern respirators contain cellulose pads to filter off the arsenic smokes

First Aid—Diagnose on symptoms and the history, and do not be deceived by the severity of the symptoms and the anxiety of the patient Apply respirator, remove to clear atmosphere Reassure the patient, recovery will occur in an hour or two Do not send to hospital If the pain in the sinuses is very severe, light chloroform inhalation will give relief For a painful nose or throat 5 per cent sodium bicarbonate solution may be used as a wash or gargle

GROUP III—VESICANTS

Mustard

Mustard is a very insidious poison It may escape immediate detection and does not produce symptoms for some hours Repeated exposure may lead to hypersensitivity Lesions may result from spray from the air, splashes from bursting bombs, or slow vaporization from contaminated buildings, ground, clothing, etc On the skin no immediate sensory effect is appreciated The poison penetrates clothing and enters the skin deeply and quickly, producing an erythema only after some hours Local oedema and capillary stasis follow, later the erythema deepens in colour, a pale centre appears, and a vesicle containing yellow serum is formed This does not contain mustard Intense

itching is usually noted and the moist parts of the body are chiefly affected Secondary infection is liable to occur and healing is slow The healed scars may be pigmented for a time.

Exposure to vapour only may produce extensive effects on the eyes temporarily blinding the subject within a few hours of exposure Contamination by droplets of splash or spray is more serious, and may lead to permanent blindness from corneal scarring Symptoms may begin within half an hour and soon the eyelids become painful and swollen. Intense oedema of the lids follows together with swelling and reddening of the conjunctiva Corneal opacities appear the ocular con junctiva may ulcerate, the tension is increased and a profuse muco-purulent discharge takes place Photophobia and spasm of the lids may be intense

If the respirator is not put on soon enough then the nose larynx, trachea, or lungs may be affected. Epigastric pain and vomiting may occur from the swallowed saliva The effects, how ever do not persist Renal complications have been noted in fatal cases. Local oedema of the penis may cause retention of urine

Mustard Vapour—If in from twelve to twenty four hours after exposure to a dilute mustard vapour the eyes become red the voice is husky, and the skin erythematous a positive diagnosis may be made Prevention consists in wearing protective clothing applying the respirator and washing in soap and water or rubbing in bleach ointment for one minute First aid consists in changing all clothing, complete bathing of the body and repeated eye lavage This suffices for mild cases Note that speed is essential cleansing must be undertaken within two minutes for liquid and fifteen minutes for vapour otherwise burns will result. The same applies to Lewisite except that the poison is appre ciated at once and the characteristic smell is always found.

Liquid Mustard—Yellow detector disks reveal splashes of mustard as bright red spots (red for danger) If clothing is found contaminated it must be removed as soon as possible, and the patient treated as mentioned above If the eyes are contaminated warm saline irrigation must be carried out immediately and be maintained at hourly intervals. In the open, water from a water

bottle should be poured into the eyes, followed by a drop of liquid paraffin

Lewisite

Lewisite resembles mustard in its action, but is less insidious It is early detected by its odour and has a shorter latent period, both in the eye and on the skin In extensive burns acute arsenical poisoning may result On the skin an immediate stinging sensation follows the application of liquid lewisite Erythema occurs within thirty minutes, vesication, too, is early, and is complete within twelve hours Clinically the effects of lewisite and mustard can now be sharply distinguished The lewisite blister is clearly defined · it covers the whole erythematous area and is filled with a cloudy fluid containing leucocytes and arsenic The mustard blister has a surround of erythema and is full of a clear yellow fluid, but contains no mustard On dry clothing lewisite is less effective than mustard, and when the clothing is wet the lewisite loses much of its effectiveness owing to rapid hydrolysis The fine spray of lewisite is even more dangerous to the eyes than that of mustard Immediate irritant symptoms follow. In fifteen minutes an acute conjunctivitis occurs, oedema of the eyelids, pain, and photophobia rapidly supervene, and in three to nine hours the whole painful picture is produced, an effect which is only seen with mustard at the end of twenty-four hours The ultimate prognosis is graver also

Since the presence of lewisite is readily appreciated the respirator is usually put on early and affords protection As in the arsenic smokes, the symptoms of irritation may appear even after the application of the respirator In the absence of a respirator nasopharyngitis follows, and bronchitis may be established in twenty-four hours, which may lead to bronchopneumonia and death

Treatment of Vesicants

Skin —So long as droplets of mustard are visible on the skin bleach ointment will lessen the severity of the burn This is made by mixing equal weights of "super-tropical" bleaching powder and white petroleum jelly. It is stable in ordinary

climates. If the contamination is extensive bleach paste is easier to apply Bleach paste consists of one part (by volume) of 'super tropical' bleaching powder mixed with two parts of water The affected area is swabbed for several minutes until no *further odour remains. Any* of the *following* solvents may be used petrol, methylated spirit, paraffin, etc Care must be taken to avoid fire the contaminated swabs after careful handling must be burned Cleansing with soap and water removes the surface gas and will prevent burns if carried out within five minutes The dresser should wear gloves. This method should not be attempted if erythema has begun but swabbing should be employed If there is a massive contamination, the application of bleach ointment is advisable In the case of established lesions, erythema if mild will clear up as in sun burn, leaving a slight pigmentation and desquamation Tannic acid jelly or solution should be useful With vesications the aim will be to prevent secondary infection Mustard burns should be treated on the surgical principles outlined by Mitchiner and others. Thorough cleansing—under an anaesthetic if necessary—is followed by the application of a tannic acid compress—layers of lint or gauze soaked in a 2½ per cent. solution of tannic acid freshly made this is left *in situ* for several weeks if desired

Eyes.—As soon as the patient comes under medical care, and while he is being cleansed in the shower baths, an opportunity is taken to irrigate the eyes with 2 per cent sodium bicarbonate solution If the eye is contaminated with liquid mustard do not wait for the onset of signs or symptoms, but continue the alkaline lavage as often and as long as possible This treatment becomes difficult as the oedema and spasm of the lids increases To relieve this apply 1 per cent. sterile atropine ointment twice a day (and in all cases where the cornea is damaged) Do *not* apply cocaine. Do *not* bandage the eyes—apply a light shade and instil liquid paraffin at frequent intervals. If the discharge becomes muco-purulent 2 per cent argyrol twice a day is indicated. The treatment of corneal ulcers with or without hypopyon, is best left to an ophthalmic expert. With vapour contamination only the prognosis is better and the patient may be immediately

reassured In mild cases irrigate every two hours with 2 per cent. sodium bicarbonate solution, instil liquid paraffin, and apply a shade or keep in a darkened room In more severe cases treat as for liquid contamination

The Respiratory Tract—Rhinitis will respond to warm douches of 5 per cent. sodium bicarbonate solution When there is laryngitis, rest the voice, keep in the fresh air, and give a paraffin spray or vapour inhalation. (*Menthol, 10 grains, tinct benzoin* 1 oz , sig , 1 drachm to a pint of boiling water.) Some 2 per cent. of the mustard cases in the Great War ended fatally. The majority of these deaths were from bronchopneumonia To prevent this complication keep cases where the lungs are involved in special wards, warm and well ventilated Isolate any case of secondary infection as it occurs Menthol is useful in allaying coughing.

As pointed out in the *Medical Manual* already referred to, it is wise to send patients as soon as possible to a special convalescent centre. This will prevent the onset of "anxiety" neurosis and such conditions as functional photophobia and aphonia Finally, doctors looking after civilian gas casualties should remember that gassing does not in itself cause a permanent state of ill health. Undoubtedly many gassed patients will develop neurasthenia and apply for disability pensions Properly handled, this state of affairs will not eventuate

Protective Measures

(1) There is a standard suit fully described in the Home Office manuals None of the recent official publications, however, mentions the important work of Major Crowden of the London School of Tropical Medicine and Hygiene Writing in the *R A M C Journal*, this officer describes a method whereby a man can continue to perform hard manual work in full protective clothing for several hours without ill effects A light drill shirt is put on over the waterproof and kept constantly wet with cold water. The loss of heat by evaporation keeps the wearer cool. (2) Several other types of clothing exist for troops in the field (3) For first-aid services there are the following. (*a*) rescue and

first-aid parties—a heavy standard suit (*b*) ambulance drivers —long coat gloves, gum boots, curtain, and respirator or eye shield (*c*) undressers—protective apron with sleeves gum boots and respirator (generally civilian duty) The methods of decontaminating clothing and buildings etc are fully described in the various Home Office manuals

GROUP IV—LUNG IRRITANTS

These gases may be discharged from air bombs or cylinders carried on low flying aircraft. The gas is heavier than air and is carried down wind Immediate application of the respirator gives complete protection, but speed is essential A single breath of phosgene may be very dangerous

Pathological Action —All lung irritants act on the bronchial tubes and alveoli causing acute pulmonary oedema A lacrimatory effect is also produced Chloropicrin is four times and phosgene ten times more toxic than chlorine On post-mortem examination the chief changes are pulmonary oedema with disintegration of the alveoli The blood becomes concentrated and tends to form thrombi. Pulmonary oedema may occur within two hours of the gassing In the first twenty four hours the lungs are found to be full of blood and are oedematous, with patches of emphysema alternating with collapsed areas. A pleural effusion may be present After the second day the oedema begins to disappear but a secondary infection leads to pneumonic patches and pleurisy The haemoglobin may rise to 140 per cent. in the blood, and is associated with pulmonary or systemic thrombosis.

Clinical Types —Two groups may be distinguished the acute type with violent onset, and the acute type with insidious onset When the onset is violent phosgene in heavy concentration and chlorine and chloropicrin will cause immediate symptoms The patient coughs, catches his breath and complains of a pain in his chest. The breathing becomes rapid and shallow deep breathing brings on a painful cough Retching and vomiting occur and the patient is knocked out. With the onset of oedema the breathing becomes rapid and shallow and the patient becomes

blue, with distended veins (see *An Atlas of Gas Poisoning*, H M. Stationery Office, 1939) In phosgene poisoning this blue phase may be passed over and quick collapse follow, with a rapid pulse and symptoms of toxic shock Here the patient may die two to three hours after exposure This group of acute cases may be classified into (1) mild cases—flushed face, increased respiration rate, and cough, (2) severe cases—"blue" type, with a full pulse, (3) severe type—"grey" type, with toxic shock Type (1) soon recover; Type (2) do well if the pulse does not rise above 100, Type (3) do badly, and death results from circulatory failure or bronchopneumonia In the group in which onset is delayed persons exposed to phosgene go on with their duties for a few hours and then suddenly collapse with a rapidly increasing pulmonary oedema, often fatal Sir William Horrocks described to me how this delayed action was discovered in 1915 Some young pigs were exposed to a low concentration of phosgene and appeared none the worse Next morning, however, they were all dead

In the early stages very few physical signs are to be found Later the percussion note may not be impaired, but the breath sounds become feeble, expecially over the back, where fine rales appear Blue cases, which respond to oxygen, may do well, and the pulmonary oedema is also over within four or five days. Grey cases with heart failure do badly. Bronchopneumonia often supervenes In the Great War 80 per cent of lung-irritant deaths occurred within the first twenty-four hours

Diagnosis—There is a distinctive smell, and the history will help Chlorine and chloropicrin produce urgent symptoms even in low concentrations Relief is immediate on applying the respirator Phosgene and diphosgene, however, even though smelt can be breathed without coughing in low but lethal concentrations Suspect casualties should be carefully questioned and examined. If it is certain the patient has been exposed to a lung irritant he should be kept at rest for twenty-four hours and watched If the exposure has been short and there are no symptoms, he may be discharged after a further twenty-four hours.

First aid must be begun as soon as a positive diagnosis is made The patient must be treated as a stretcher case be kept warm and as quiet as possible, and be put on a light diet. Make preparations for giving oxygen and performing venesection if signs of lung injury supervene (dyspnoea tachycardia cyanosis, frothy expectoration, and concentration of the blood)

Treatment of Established Cases —Suspect cases must be kept at rest and observed for twenty four hours If no symptoms have arisen in the next twenty four hours they may be discharged. In the acute stages the treatment consists in rest warmth, venesection, and oxygen If the patient is tided over the first few days the oedema will absorb and recovery is possible Treat all lung casualties as stretcher cases and after admission to hospital keep them quiet in bed All contaminated clothing must be removed as soon as possible As in the treatment of wound shock, it is most important to keep the patient warm. Venesection is carried out on the appearance of cyanosis 15 to 20 oz. (400-600 c.cm.) are withdrawn through a needle It is possible that further experience may show that subsequent introduction of normal saline intravenously may be beneficial If the cyanosis deepens and pulmonary oedema increases, oxygen is initiated. Venesection is harmful to the grey cases. Oxygen may be required to be given continuously for some days. Nurses should be instructed in the use of an oxygen tent, closed or open pattern, nasal catheter or Haldane's mask. An average of five litres a minute will be required for each patient. In the Great War it was found that no patient in whom a pink colour was obtained by the use of oxygen died from pulmonary oedema

Expectoration may be encouraged by posture The Tor table (Mitchiner and Cowell) provides a simple method of lowering the patient's head to allow the serous fluid to escape from the lungs. No drugs were found to be of value in the Great War If pneumonia supervenes some of the new drugs may be tried but no opportunity has yet arisen to test their efficiency under these conditions In treatment of the convalescent the remarks made with regard to mustard will apply here also

blue, with distended veins (see *An Atlas of Gas Poisoning*, H M Stationery Office, 1939.) In phosgene poisoning this blue phase may be passed over and quick collapse follow, with a rapid pulse and symptoms of toxic shock Here the patient may die two to three hours after exposure This group of acute cases may be classified into (1) mild cases—flushed face, increased respiration rate, and cough ; (2) severe cases—" blue " type, with a full pulse , (3) severe type—" grey " type, with toxic shock Type (1) soon recover , Type (2) do well if the pulse does not rise above 100 , Type (3) do badly, and death results from circulatory failure or bronchopneumonia In the group in which onset is delayed persons exposed to phosgene go on with their duties for a few hours and then suddenly collapse with a rapidly increasing pulmonary oedema, often fatal Sir William Horrocks described to me how this delayed action was discovered in 1915 Some young pigs were exposed to a low concentration of phosgene and appeared none the worse Next morning, however, they were all dead

In the early stages very few physical signs are to be found Later the percussion note may not be impaired, but the breath sounds become feeble, especially over the back, where fine rales appear Blue cases, which respond to oxygen, may do well, and the pulmonary oedema is also over within four or five days Grey cases with heart failure do badly Bronchopneumonia often supervenes In the Great War 80 per cent of lung-irritant deaths occurred within the first twenty-four hours

Diagnosis —There is a distinctive smell, and the history will help Chlorine and chloropicrin produce urgent symptoms even in low concentrations Relief is immediate on applying the respirator. Phosgene and diphosgene, however, even though smelt, can be breathed without coughing in low but lethal concentrations Suspect casualties should be carefully questioned and examined. If it is certain the patient has been exposed to a lung irritant he should be kept at rest for twenty-four hours and watched If the exposure has been short and there are no symptoms, he may be discharged after a further twenty-four hours

First aid must be begun as soon as a positive diagnosis is made. The patient must be treated as a stretcher case be kept warm and as quiet as possible, and be put on a light diet. Make preparations for giving oxygen and performing venesection if signs of lung injury supervene (dyspnoea tachycardia, cyanosis frothy expectoration and concentration of the blood)

Treatment of Established Cases—Suspect cases must be kept at rest and observed for twenty four hours. If no symptoms have arisen in the next twenty four hours they may be discharged. In the acute stages the treatment consists in rest, warmth, venesection and oxygen If the patient is tided over the first few days the oedema will absorb and recovery is possible. Treat all lung casualties as stretcher cases and after admission to hospital keep them quiet in bed All contaminated clothing must be removed as soon as possible As in the treatment of wound shock, it is most important to keep the patient warm. Venesection is carried out on the appearance of cyanosis 15 to 20 oz. (400-600 c.cm.) are withdrawn through a needle It is possible that further experience may show that subsequent introduction of normal saline intravenously may be beneficial. If the cyanosis deepens and pulmonary oedema increases oxygen is initiated Venesection is harmful to the grey cases. Oxygen may be required to be given continuously for some days. Nurses should be instructed in the use of an oxygen tent, closed or open pattern nasal catheter or Haldane's mask An average of five litres a minute will be required for each patient In the Great War it was found that no patient in whom a pink colour was obtained by the use of oxygen died from pulmonary oedema.

Expectoration may be encouraged by posture The Tor table (Mitchiner and Cowell) provides a simple method of lowering the patient's head to allow the serous fluid to escape from the lungs No drugs were found to be of value in the Great War If pneumonia supervenes some of the new drugs may be tried but no opportunity has yet arisen to test their efficiency under these conditions. In treatment of the convalescent the remarks made with regard to mustard will apply here also

GROUP V—PARALYSANTS

The diagnosis of this group presents no difficulties *First Aid*—For both HCN and H_2S, prolonged artificial respiration with administration of O_2 and CO_2 is indicated In these cases some form of artificial respiration by apparatus, such as an "iron lung", Eve-Riley rocking stretcher, or the Tor tilter, may save life Full details are to be found in the *Medical Manual of Chemical Warfare*

SURGICAL TREATMENT OF GAS CASUALTIES

It will probably be found that the number of wounded and gassed cases will vary inversely—that is, there will be wounded only and no gas, or vice versa In individual cases decisions must be made according to the circumstances A man contaminated with mustard must be stripped and cleansed and reclothed before being admitted to the pre-operation ward and theatre General anaesthesia may be inadvisable in the case of lung-irritant poisoning, but gas-and-oxygen preceded by menthol inhalation will probably be safe in mild cases Operating theatres, as already noted, should be splinter-proof and gas-proof If these precautions have not been taken the surgeon and all the members of his team should be prepared to work in respirators if necessary

CONCLUDING REMARKS

Undoubtedly many gas casualties will arise among women and children The children will require extra nurses, and will probably fare worse than adults I saw infants with mustard burns in some of the villages near the line in France during the last war, but only in small numbers They made constant demands on their mothers

When gunpowder was introduced the men of the time said, "How terrible, cannot we go back to the humane bow and arrow?" The same has been said of chemical warfare But with careful education, preparation, organization, discipline, and determination it will be easier to protect the people of this country against gas than against high-explosive or incendiary bombs

A short bibliography is given below for a very full list of authors (826) the reader is referred to Hanslian, vol. 1 *Der Chemische Krieg* 1939

I wish to acknowledge my indebtedness especially to the most excellent *Medical Manual of Chemical Warfare*, 1939 which should be read by all doctors.

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DETONATION OF HIGH EXPLOSIVE IN SHELL AND BOMB, AND ITS EFFECTS

By DAVID DALE LOGAN, D S O, M D., F R F P S G., D.P H, M I M.E

In the official *Medical History of the War,* in order to show how little novelty there is in warfare and to point out that mining dates back to remote antiquity, I quoted an ancient historian who described the use of asphyxiating gas in mining at the Siege of Ambracia in the year 189 B C. On that occasion the Aetolians filled jars with feathers These feathers were then set on fire and the resulting smoke blown by billows into the faces of the Romans 189 B C.[1] Yet the method adopted by the Germans more than a thousand years later was somewhat similar

In France, in 1917, a group of collieries in the Bethune district was one of the few remaining fields in active operation. Although one of the collieries, Fosse 8, in this very important mine system was in enemy hands, and all the shaft heads and the mining villages of Annequin, Vermelles, Philosophe, etc, had been frequently shelled, the French had been able to continue working. At the height of the submarine menace, when there was an urgent demand for coal by the French, the Germans made a determined effort to stop production in these collieries Unfortunately the French had delayed building off Fosse 8, which was still used as a downcast shaft. Great quantities of chloropicrin gas were thrown down this shaft Powerful fans, the modern development of the bellows used by the Aetolians, were installed in one of the collieries. These carried the gas to all quarters of the system, killing many French miners who were at work, and also members

the bottom out of an ironclad at midnight, thus throwing four or five hundred men into the sea to be choked by water, with scarcely the remotest chance of escape"

Those who have had much experience of gas warfare know that of all modern weapons it is the most humane, or perhaps I should say, the least inhuman, as it causes the least amount of suffering, the smallest percentage of deaths, and by far the greatest percentage of complete recoveries Proof of this may be obtained from the official medical histories issued by the various combatants in the great war and from standard works on gas and chemical warfare

In 1937 the Representative Body of the British Medical Association passed the following resolution

"That this Meeting condemns unreservedly the use of poison gas in warfare as inhuman in its results and degrading to civilization and relies upon the Council to do everything in its power with a view to securing the co-operation of the medical profession of all countries in order to prohibit the use of poison gas"

As no mention of high explosive shells or bombs was made, the use of these in modern warfare must be considered legitimate and humane Those who were responsible must have been ignorant of the authoritative sources of information I have given Perhaps they preferred the work of H G Wells In his book, *The Shape of Things to Come,* there is the following description of gas warfare

"The tortures of gas were already many and various, and most of the mixtures then used left tormenting weakness in the system for the rest of life" Further on he declares that "gas warfare ranks in horror with the story of judicial torture or the story of ritual cannibalism, but its inhumanity is more striking because of its nearness to our time"

In his *History of the Next Hundred Years* he describes, most incorrectly, the effects of mustard gas

"It is doubtful if any of those affected by it were ever completely cured Its maximum effect was rapid torture and death, its minimum, prolonged misery and an abbreviated life"

After I had finished reading the B M.A. resolution I read in

the daily newspaper that in Cleveland, U S.A. forty constables dispersed with tear gas 600 strike pickets and their supporters! In France, as early as 1912 lacrimatous grenades had been used by the military in civil disturbances, and Prentiss in his great work, *Chemicals in War* very pertinently points out

No Government can be open to criticism for using against an invading army weapons already employed against its own unruly nationals (p 688)

LEGITIMATE GAS WARFARE

Few people realize that, with what might be termed the legitimate weapons of modern warfare in which explosives are used, many casualties from gas poisoning occur During the great war thousands of casualties from gas poisoning were caused by shells, trench mortars, bombs and aerial torpedoes bursting in deep trenches, dug-outs, cellars, concrete structures, and enclosed places, as well as in ships. Casualties from gas poisoning also occurred from mobile charges used to destroy dug-out systems, from bombs bursting in houses and flooding basements with gas from the bursting of gas mains and pipes, and from many other causes.

Carbon monoxide was the most dangerous gas encountered in military mining After a mine was exploded the galleries were filled with gas. In some cases this welled up the shafts and flooded the surrounding trenches poisoning the occupants. Gas poisoning occurred in gun pits, in closed machine-gun emplacements owing to the blow back in tanks from leakage of exhaust and from the use of coke braziers in cellars, dug-outs, and other confined places. As the official *Medical History of the War* properly states, in all these cases the primary object for which the explosive was employed was its destructive effect, and it was to chance rather than to design that one must attribute the deadly effects of the fumes

When the First Hague Conference was discussing the employment of projectiles the sole use of which is the diffusion of asphyxiating or deleterious gases, it was pointed out that, when H.E. shell detonated, poisonous gases were generated which

might cause death in confined areas After discussion the Conference ruled that, *if the splinter effect of a shell was greater than its noxious-gas effect, it would be regarded as a legitimate weapon, but if the gas effect were greater it should be banned* That is to say, allowance was made for the gases which are necessarily produced by high explosive shells Gas was forbidden, but the most cruel and devastating of modern weapons, H E shells and bombs, received the sanction of the Conference Prentiss very properly points out that the question of what projectiles were permissible within the meaning of the First Hague Conference was never actually put to the test, because, when gas warfare did begin on a big scale, it was not by projectile but by drift gas from cylinders

Those who have extensive knowledge of the use of gas in warfare are greatly relieved that those in authority have recovered from their obsession regarding the importance of gas attacks from the air They have now come into line with other countries which regard protection against H E bombs as of major, that against gas as of minor, importance It is therefore much more important to study the use and effects of high explosives than those of gas poisoning, just as it is more important to provide splinter-proof shelters than gas-proof rooms

HIGH EXPLOSIVES

In connexion with defence against aerial bombing certain important facts regarding explosives should be known to all doctors

High explosives depend for their action upon the instability of the chemical equilibrium of their constituents They are of compounds of carbon, oxygen, nitrogen, and hydrogen, so feebly combined that, when fired by combustion or detonation, new, simpler, and more stable compounds are formed Once chemical action is started it proceeds with great velocity and the explosive is immediately converted into gases with the evolution of heat These gases, now occupying an enormously greater volume than the original substance, have powerful disintegrating properties High explosives are very violent, detonating at the rate of several

miles per second many times greater than the most violent hurricane In explosives used to propel bullets shells, etc. the combustion is much slower The violence and shattering effect of the explosive depend upon the velocity of detonation which varies in different explosives and also upon the amount of gas and heat generated. To effect detonation of high explosive a detonator is used, which, in its action, corresponds to a very violent and sharp blow accompanied by heat and flame

Generally speaking explosives contain an excess of oxygen, and theoretically, should give rise to little carbon monoxide But they vary much in this respect, and in the conditions under which they are generally employed produce considerable quantities of this gas Shells give rise to less carbon monoxide than bombs or mobile charges. In all of these if from any cause—deterioration of explosive insufficient detonators etc —the wave of detonation dies out, and a slower form of combustion results, incomplete or partial detonation is said to have taken place. In this event the products of combustion are altered, much more carbon monoxide and, in addition, nitrous fumes being formed

When a high explosive is ignited it burns at the rate of a few feet per second. During the war explosive salved from the enemy and from mines, which could not be used was laid out in long lines and destroyed in this way The products of combustion are quite different from those of explosion or detonation very large quantities of carbon monoxide and nitrous fumes being formed Such accidents occurred in the Navy during the war and, in gold mining on the Rand several accidents, where stores of explosive underground were accidentally set on fire have been reported.

Notwithstanding the colossal scale on which explosives were used during the war no epoch making discoveries were made and none have been made since. Nitro-glycerine, which was discovered in 1846 still remains the most powerful high explosive. The large number of new explosives used during the war and others which have appeared since are merely new mixtures of substances which have been used for many years, some the natural outcome of shortage of certain materials. All the Powers

at war, with the exception of Germany, used practically the same types of explosives The Germans during the latter months of the war used liquid air very extensively as an explosive for demolition work, and for blasting operations in making dug-outs and tunnels They were also the first to use liquid oxygen for supplying oxygen to airmen at high altitudes

Very valuable information regarding explosives was gained from the extensive mining operations which were carried out on the Western Front Never before had explosives been employed on such a huge scale The fact that in 1916 the enemy fired 700 mines, and the British nearly 750, will convey some idea of the intensity of mine warfare For a considerable period 30,000 men were engaged in active mining and in making underground protection for the troops

It is the same in connexion with chemical warfare as with explosives, for to-day, twenty-four years after the start of this type of warfare, the two most effective gases belong to the phosgene and mustard gas groups It is necessary to insist that the deadliest gases cannot be used in aerial warfare

Most people have a very vague knowledge of explosives, this probably explains their easy belief in fantastic stories of the discovery of wonderful explosives of extraordinary power, tales of which are so often circulated by the press One recalls the report circulated soon after America entered the war of a new American explosive, a tablespoonful of which would uproot St Paul's After the battle of Messines, when nineteen huge mines containing tons of high explosive were blown, it was amusing to read the statement of one famous correspondent that one pound of ammonal—the explosive used—could blow the Mansion House to pieces Tales of a similar kind have appeared at regular intervals in recent years, indeed they are a striking feature of the Secret Service and detective novels so widely read

LIQUID OXYGEN AND LIQUID AIR AS HIGH EXPLOSIVES

A few months ago several newspapers harrowed the feelings of their readers by describing the devastating effects of a new bomb which had come into the possession of the Germans and

which had been used in Spain. The high explosive in this bomb was liquid oxygen It was half the weight of other bombs and its explosive energy was said to be many times greater What are the facts? This explosive has been in use for many years. It was first employed on an extensive scale in the making of the Simplon Tunnel, where operations had been seriously affected and delayed by the dangerous contamination of the atmosphere from blasting by nitro-glycerine explosives. It was found safe to handle powerful in action, and, except in most exceptional circumstances, did not produce poisonous fumes. Liquid air plant was installed and liquid air was used on a large scale to improve ventilation. After a short trial owing to practical difficulties its use was abandoned.

For a few years before the war the Germans had been using liquid air as an explosive in mining and quarrying In the later years of the war Germany had available abundant supplies of liquid air from the manufacture of nitrogen and great efforts were made to render it more practicable and efficient. In 1917 and 1918 they used it for blasting in connexion with the construction of mine galleries dug-outs etc and for carrying out demolitions. Towards the end of 1917 I took part in an investigation into its use as an explosive Most valuable information was obtained from a South African mining engineer who had a very large experience of blasting with this explosive Engineers on the Rand have had many bitter experiences of the fouling of the atmosphere underground by high explosives. As the death rate from this among native labour was very high, strict precautions were taken, and in many mines compressed air and liquid air were in constant use to purify the air The following were the principal reasons for abandoning their use as an explosive on the Rand The same reasons prevented their adoption by the British during the war

One great drawback to liquid air as an explosive, even when the cartridges were charged *in situ* is its variability the explosive power of the charge depending upon the proportion of oxygen in the cartridge, which necessarily varies from moment to moment. It is therefore less reliable, less efficient, and its results

less easily controlled than other high explosives Another important point is that, although weight for weight liquid air is more powerful than gelignite and other explosives—in other words its explosive energy is greater—with the type of cartridge used, bulk for bulk, it is less powerful As a result the diameter of the drillhole has to be twice that required for gelignite, etc This was a serious drawback to its employment in mining I understand that Woolwich Arsenal turned it down as useless for propellant work and for bombs

INFLAMMABLE AND EXPLOSIVE GASES FROM DETONATION OF HIGH EXPLOSIVE IN BOMBING, ETC

The gases from the detonation of a high explosive vary in quantity and in composition according to the quality of the explosive used and also to other conditions Those generally found are hydrogen, carbon monoxide, and methane (CH_4), all of which are combustible, and, when present in the proper proportion, explosive Anything which prevents the carbon in the explosive being converted into CO_2, and the hydrogen into H_2O, will result in large quantities of H, CO, and CH_4 being formed This will happen when there is imperfect detonation of part of the charge Methane is never formed at the time of explosion, but results from the action of hydrogen on the oxides of carbon as the gas cools down The greater the amount of hydrogen formed, the greater will be the proportion of methane

Explosives containing T N T give rise to considerable quantities of hydrogen and methane When any of the ammonium nitrate group of explosives are detonated in the open—for example, mobile charges, bombs, etc —more CO, H, and CH_4 are found than when the explosive is detonated after being tamped In some of the secondary explosions which I investigated during the war all these gases were present, but in others there was so little CO that canaries exposed to the atmosphere were unaffected

The tendency of the gases to explode will depend on certain factors (1) The amount of gas present—the larger the bomb the greater the volume of gas, (2) composition of gases, (3)

velocity and density pressure and concentration of the gas. The greater these are the greater will be the liability to explode Where gas is present in insufficient volume or in unexplosive percentage and is ignited the flame becomes spent

The damage done to tunnels or dug-out systems by the explosion of gases from detonation of high explosive is generally limited to a small area and will depend upon the force of the explosion and be much greater where the tunnels and galleries are large much smaller when they are narrow Even when explosives are used on a comparatively small scale in blasting enough gas may be given off to cause an explosion The following is an example

In making a deep dug-out in very hard chalk cheddite was used for blasting Of the four shots fired two failed to detonate one detonated imperfectly and one completely After twenty minutes had elapsed the men returned to the face to examine the effects and an explosion occurred Inquiry subsequently showed that in this case the explosive used had been stored for a long time with consequent deterioration.

During the war attention was first directed to the explosibility of gases formed from the detonation of high explosives. In January 1916 a tunnelling company suffered considerable casualties, the officer another officer and sixteen other ranks being killed As this conveys a very good lesson of one of the great dangers of military mining and *an entirely unknown danger of bombing* I shall give a short description of what occurred. *Until this disaster was investigated the danger of carrying a naked light into galleries in which gas was known to be present was not appreciated*

The enemy exploded a camouflet—that is, a mine which did not break the surface or crater The explosion was not intense and damage done to one gallery was small. It is probable that the mine had been charged for some time and the explosive had deteriorated At the time four officers and a considerable number of men were in the galleries. There was an order that as soon as an explosion occurred everyone must leave the mine an attempt was made to carry this out, but before this could be

effected a secondary explosion occurred The two officers near the site of the explosion were killed by the force of the explosion, both showing extensive burns, the sixteen men, who were at a considerable distance from the point of explosion, were killed by carbon monoxide The mine rescue men were able to save a large number of the men As a result of this an order was issued that no naked lights were to be used in the galleries till these were proved clear of gas Electric lights were always to be employed when gas was known to be present

Bombs and aerial torpedoes on detonation give rise to large quantities of gas, the CO content of which will be greatly increased if part of the charge is imperfectly detonated Hence when they incompletely detonate in houses, the occupants of the cellars and basements are not only exposed to the dangers of gas poisoning against which the gas mask offers no protection, but they run the risk of gas explosions and fires During the war in air raids on cities and towns and villages serious gas explosions and fires occurred and many lost their lives

The gas thus produced may be ignited by the great heat resulting from the detonation of the bomb, or by incendiary bombs, or by the presence of a naked light As bombs penetrate deeply before detonating gas may be given off from the ground slowly, and very gradually collect in cellars and basements, to be fired by someone approaching with a naked light, sometimes it may be hours after the bombardment has ceased In other cases gas has found its way into cellars at a distance from the exploding bomb by passing through fissures that have been caused by the explosion Serious gas explosions and fires were also caused by the ignition of illuminant gas that had escaped from pipes smashed by the explosion. These explosions may occur during salvage work among the debris when pockets of gas may be fired

It is an obvious precaution to make use of electric torches during all operations where gas is suspected, and, after an air raid, never to enter a cellar with a naked light

CARBON MONOXIDE POISONING FROM DETONATION OF H.E SHELLS, BOMBS, AND MOBILE CHARGES IN CLOSED PLACES

By DAVID DALE LOGAN D.S O M.D F.R.F P.S G D.P.H M.I.M.E

When shells and bombs burst in the open carbon monoxide with its specific gravity of 0·96 (slightly lighter than air) is quickly dissipated, which makes it useless in offensive gas warfare. In deep trenches under favourable (that is, dull) heavy atmospheric conditions, violent and prolonged bombardment may cause a collection of CO high enough to cause poisoning British French, and German observers have proved this by finding CO in the blood of men killed or wounded during the shelling and by observing symptoms of poisoning—headache giddiness, sickness, loss of consciousness—in a number of those exposed. These symptoms were generally regarded by the men as the result of the noise and the shock of shells bursting in their vicinity Carbon monoxide has also been discovered in the blood of men killed by the bursting of shells, which, though close to them, had caused no apparent wounds, and in the blood of men found in a state of shock under similar conditions This has been confirmed by French and German investigators

Before it was generally recognized that CO poisoning in dug outs and in other enclosed places may follow dense salvos of high explosive shells, cases of fulminant gas poisoning from detonation of heavy shells, used in 1916 on a vastly increased scale, gave rise to the belief that the different combatants were using a new asphyxiating gas. This idea was strengthened by

stragglers from various units The bombardment blocked all the entrances, and the galleries were flooded with fumes from the high explosive shells, which asphyxiated most of the occupants, a considerable number of whom died. Six hundred survivors were taken prisoners.

The Tunnel Cornillet held by the Germans was composed of three galleries each a thousand feet long and eleven feet broad. There was an exit from each gallery Ventilation was obtained from hand fans and from a number of ventilating shafts in the roof There was accommodation for three battalions. During the French attacks salvos of shells bursting near the entrances already sealed by the explosions, gassed the pioneers and prevented them freeing the entrances. Next day a large shell penetrated the tunnel doing great damage, and another came through the ventilating shaft Many of the garrison were poisoned by carbon monoxide and a large number died. The rest were so demoralized that no attempt was made to clear the entrances. Many prisoners were captured In this case very few deaths were caused by direct violence The vast majority were the result of gas poisoning

HOW SUCH ACCIDENTS WERE PREVENTED

In modern trench warfare and aerial warfare adequate underground protection is all important The British defence on Givenchy Ridge in April, 1918 forms an excellent example of how the effects of intense shell fire on dug-outs may be combated and supports Professor Haldane's plea for deep underground protection in A.R P

Several attempts were made by the enemy to capture the Ridge, each attack being preceded by heavy shelling which however failed to crush the entrances to the deep dug-outs. Three of the entrances were protected by ferro-concrete monoliths each with a minimum thickness of four feet one entrance was in a cellar strengthened by rails and a bursting course, and three other entrances were covered by elephant shelters with a triple course of rails and five feet of broken bricks as a bursting course. Gas, either from explosives or from gas shelling, was

prevented from gaining admission to the dug-outs by efficient gas curtains and gas doors The troops were thus perfectly safe, as was abundantly proved by the success of the counter attacks which cleared the enemy off the high ground

Gas from the detonation of shells, bombs, mobile charges, minenwerfers, etc , has been known to gain an entrance into cellars and dug-outs at some distance from the burst through fissures in the strata or through cracks in the walls of the buildings In an intensive bombardment by heavy shells or by bombing, the ground in the affected area may become saturated with gas This is more likely to occur if there has been imperfect detonation of the explosive, or if heavy shells and bombs with time-fuses have penetrated so deeply that when detonation occurred no craters formed In all these cases gas may find its way into cellars, basements, or dug-outs by percolating through the porous ground or through crevices formed in the ground It is well to remember that when gas percolates through soil it loses its distinctive odour and becomes all the more insidious

On the Western front hundreds of deaths from CO poisoning resulted from the detonation of mobile charges used for destroying dug-outs and subways. The following is a good example of what happens, and it also shows the great value of efficient rescue work

Preliminary to a hostile raid there was an intense bombardment of the British front line trenches The ventilation of the infantry tunnel was seriously disturbed by the detonation of minenwerfers which crushed in two of the entrances Shortly after shelling stopped the entrance to the shaft leading to the tunnel was blown in by a mobile charge brought over by the enemy raiding party A demolition of our own which was in the shaft mouth was fired by the action of the enemy charge Of thirty-six men who were in the tunnel, twenty-five lost their lives by CO poisoning before they could be rescued Mine rescue men with apparatus were quickly on the scene and succeeded in rescuing and resuscitating eleven men, all of whom were unconscious and seriously affected All these men required oxygen, most of them artificial respiration In two cases oxygen

administration was kept up for ten hours All recovered The enemy mobile charge which detonated our charge at the shaft mouth had given rise to large quantities of gas.

It is well to remember that very often more gas is given off when explosives in large quantity are fired in the open than when the explosive is fired after being properly tamped. The fact that ventilation, owing to the entrances having been previously crushed in was defective would accentuate the action of CO and the presence of even small percentages of CO would, under such conditions, have serious consequences

Many cases similar to the above were caused during the frequent British raids on the enemy lines, the tunnellers, who accompanied the infantry carrying over very heavy mobile charges of high explosives. Owing to the high concentration of CO in these cases, and to the difficulty of setting up good ventilation, the entrances having been destroyed death would follow very quickly In some places where there was incomplete detonation of the charges nitrous fumes as well as CO were formed.

CAUSE OF DEATH OF OCCUPANTS OF CONCRETE SHELTERS SUBJECTED TO BOMBARDMENT OF HEAVY SHELLS AND BOMBS

Recently questions have been asked regarding the effect on the occupants of concrete shelters of severe concussion from the detonation of bombs Although aerial bombing owing to the considerable intervals between bursts is entirely different from intensive bombardment by shells, it is interesting to recall some experiences during the war

The nature of the ground on Messines Ridge, where there is a water bearing sand about twenty feet below the surface made the construction of dug-outs impossible Ferro-concrete shelters were therefore used and proved of the greatest value in resisting shell fire. A large proportion escaped serious damage, although the entrances were blocked It is very questionable if the occupants of these concrete shelters could remain in a condition able to fight or even to survive under repeated concussion from the bursting of heavy shells. It was quite common to find the

occupants dead in shelters which had been hit, but not penetrated, by eight-inch shells. In these cases there was no question of gas A number of these shelters in the village of Messines were practically intact, and yet the wood lining and everything inside was shattered into many pieces, showing that the concussion must have been terrific. Anyone who has experienced, as I have machine-gun fire in a "pill-box" knows the painful effect the concussion has on the ears, and this would be many times less than the effect of heavy shells landing. Commotio cerebri would be caused by the intense vibration being transmitted through the bony structures to the central system. Various methods were adopted to lessen the intensity of the shock, but without success After their painful experience at Messines and Langemarck, it was quite common for the enemy to leave the pill boxes during heavy shelling and get into neighbouring shell holes, returning to the pill boxes when the barrage lifted.

IMMEDIATE EFFECTS OF DETONATION OF HIGH EXPLOSIVES

It is very necessary to understand what happens when a large shell, trench mortar, bomb, or mobile charge explodes Before considering this I should point out one great difference between shells and bombs or mobile charges. The high explosive content of a projectile from a gun is greatly reduced by the thick walls of the shell which are necessary to withstand the shock of discharge. The mobile charge or the bomb, on the other hand, is nearly all high explosive.

When a charge of high explosive is detonated there is first, an enormous expansion of gas. This is referred to as expansion, or explosive wave, or simply as blast, and corresponds to the French "vent du projectile". This is followed by another wave, a tremendous inrush of air, which has been variously described as recoil, suction, or aspiration. Sir Frederick Mott, from the various pathological findings, refers to the first as the wave of compression, and to the second as the wave of decompression. Some observers hold that the latter has even greater destructive action on the human body than blast.

It is not necessary in this article to describe the extraordinarily

varied effects of bombing on buildings in cities and towns. This has been very vividly described and minutely detailed by Professor J B S. Haldane John Langdon Davies, and other writers from their recent experiences in the Spanish War In order to illustrate the two explosive waves, let me quote Professor Haldane in his most interesting and informative work *A.R.P.*, which I advise all doctors to read He describes how when bombs burst in a Spanish street, the metal shutters of shops

Diagram of the Effects of an Explosive Wave

NOTE.—The size of the zones A and B will depend on the amount of explosive in shell or bomb.

which had not been knocked down were sucked outwards, and when a bomb fell inside a house a large part of the shattered walls fell inwards.

By far the greatest number of casualties resulting from detonation of heavy H E shells and bombs is caused by flying pieces of shell brick, stones, and debris which are impelled at great velocity and may cause death hundreds of feet from the exploded bomb or shell. A considerable percentage of the casualties are caused by crushing, by burying, and by asphyxiation from the collapse of buildings, entrances to cellars, dug-outs, etc

Inside the zone of maximum violence bodies may be torn to pieces and mutilated by the force of the explosion Men may be hurled by the force of the explosion and smashed against buildings or against the ground

Wounds produced not by missiles, but by the explosive waves, may be produced (*a*) from without inwards, this due to the enormous compression and velocity of the gases (the explosive wave travels many times faster than the fiercest hurricane), or (*b*) from within outwards, during the recoil

To give some idea of the intensity of the blast, Sir Frederick Mott, in his book, *War Neurosis and Shell Shock*, quotes the American Medico-Military Report, which stated that an "aneroid showed that the explosion of one of these shells caused a sudden atmospheric depression of about 350 mm of the mercury tube, corresponding to a dynamic pressure of about ten tons to the square yard".

There is no doubt that many cases of sudden death, where no wounds were found, were caused by the severity of the blow over the heart or epigastrium Sir Frederick Mott believes that the enormous aerial compression "may be transmitted to the fluid about the base of the brain and cause shock to the vital centres of the floor of the fourth ventricle causing instantaneous arrest of the function of the cardiac and respiratory centres" This, he held, explained many of the cases of sudden death where there were no visible injuries to the body In describing a personal experience of his own during the war when he was in the vicinity of bursting shells Professor Haldane thought that death in some similar conditions might be due to paralysis of the breathing

The second, from within outwards, explains the bursting open of cavities as well as the extensive and strange character of the wounds occasionally noticed in the vicinity of explosions After the bursting of large shells, bombs, and trench mortars near dug-outs or cellars, the parts of the body which would be affected by the suction are those which contain gas, and one would expect to find conditions similar to those produced in accidents in caissons but more exaggerated

buildings, etc, it must be remembered that in modern warfare life would be impossible without adequate underground shelters, and that these undoubtedly saved many thousands of lives during the great war In an article in the *Spectator* in February 1939 I pointed out that "the experience of the war and recent experiences in Spain proved that nothing so quickly gives confidence and allays panic in heavy bombardment by high explosive shells and bombs as the provision of efficient underground shelters The imperative duty of the Government is the adequate provision of large underground bomb-proof shelters in those cities and towns which are likely to be attacked Underground accommodation for hospitals on a large scale should be commenced at once The bombing by the Germans during the war of the crowded hospitals at Etaples may be remembered by many I saw the ghastly results Hundreds of the patients, doctors, nurses, and staff were killed or wounded"

These opinions, I may add, have in no way been affected by the last authoritative pronouncement on the subject, which rejected deep underground protection against bombing as *unnecessary and undesirable, as well as being economically* impossible

ANIZATION OF THE EMERGENCY MEDICAL SERVICES

1 HOSPITALS

By W A. LETHEM M C MD

war hospitals and other buildings or private houses be used as hospitals, come under the general direction ter of Health. Existing hospitals will however con administered by their own governing bodies while ed as hospitals will be administered either by one of cal authorities or by a neighbouring hospital.

CLASSIFICATION OF HOSPITALS

have been classified into three categories Class 1 which are capable of giving full surgical treatment titutions such as Poor Law institutions and con omes, which are capable of providing reasonable lities and Class 3 infectious diseases hospitals. s 1 has again been divided into (*a*) hospitals of over fifty s, and (*b*) hospitals of under fifty beds. Separate wings or ds *of mental hospitals* are also being used and may be graded Class 1 or 2 according to the facilities available. The few ting Service hospitals will, as far as possible be reserved for vice cases, though wounded civilians will be taken in if neces- y for temporary shelter pending removal to a civilian hospital. vice casualties will also be treated in civilian hospitals.

Many Class 2 hospitals are being upgraded to the status of s 1 by the provision of operating theatres and equipment,

This article was written before the outbreak of war and the arrangements ribed in it are now in force without material alteration.

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gical hospital though in time special types of cases will be nferred to the care of surgeons with specialized experience ternity wards or hospitals and infectious diseases hospitals h one or two exceptions will not be used for the reception casualties In country districts where a large increase in ulation is expected many of them are being expanded by the horities responsible

DISTRIBUTION OF PATIENTS

lthough in practice it is impossible to protect a hospital com ely from the effect of air raids some form of protection can ally be provided Memorandum E M S No 1 of the Ministry Health makes detailed recommendations of the precautions ch should be taken and the terms under which financial help be given. No one can foresee with any certainty where ualties may occur but while every suitable hospital is expected ake in and provide temporary shelter for persons injured in mmediate neighbourhood permanent treatment will only be vided in those hospitals which experience shall show to be sonably safe. For this purpose most of those in the larger ns have been grouped or affiliated with those in the surround country to which their cases, and if need be some of their f, will be transferred

he essence of the scheme is fluidity and it may well happen t patients will have to be moved either by road or rail for paratively long distances Ambulance trains with a carry capacity of over 10 000 stretcher cases, will be formed by verting brake vans to take stretchers by means of special ings which have already been manufactured and stored e of the advantages of central control is that there is no rigid of demarcation between one district and another and ients may be treated wherever suitable accommodation is ilable.

ADMINISTRATIVE PERSONNEL

he Director-General of the Emergency Medical Services and staff at the Ministry of Health are supported by Consulting visers" leading physicians and surgeons representing all

while certain selected hospitals in safe areas are being expanded by the provision of extra beds and by the erection of huts, each calculated to take forty beds Structural improvements and alterations are being made in many of the buildings, and additional sanitary and cooking facilities provided where required to enable them to cope with an increased number of patients These adaptations and temporary fittings are not of the standard usually found in first-class hospitals, but, if not elaborate, they at least enable first-class work to be done without throwing too great a strain on the medical and nursing staffs The cost of the adaptations is being borne by the Ministry—in voluntary hospitals up to 100 per cent and in publicly owned hospitals up to 70 per cent, with a maximum liability on the local authority of one-tenth of a penny rate Full particulars of the whole scheme are given in an official publication of the Ministry of Health, Memo. No 2, which can be obtained from the Stationery Office or through any bookseller.

Many country houses have been offered to the Government, as in the last war, but with a few exceptions they have not been accepted owing to the difficulty of adapting them for acute surgical work and of providing skilled staff. If the war lasts for a long time, and if many of the towns continue to be unsafe for habitation after the first few months, no doubt accommodation for convalescent cases would have to be found But that is a problem which can be met when it arises The accommodation required for civilian casualties is very different from that necessary for the combatant services, which are under an obligation to house and keep their personnel, preferably in disciplined units, for as long as they remain in the forces A convalescent civilian casualty can be discharged to his own home, to the care of his friends, or to a billet if he has no home to go to, as soon as he is no longer in need of in-patient hospital treatment

Certain hospitals or parts of hospitals, suitably staffed, have been set aside for the treatment of such conditions as jaw injuries, nervous troubles. and other cases requiring specialized treatment Probably a very high percentage of all casualties will be classified as orthopaedic. and at first will have to be admitted to any

well clear of it. Much of the valuable *x* ray and other therapeutic equipment in the central hospitals is also to be moved out to safer hospitals at the earliest opportunity

WAR TIME MEDICAL APPOINTMENTS

The war will be accompanied by big changes in the distribution of population, resulting not only from the Government's evacuation scheme, but from the increased demand for labour of all kinds in different parts of the country and medical practice must adapt itself to the altered conditions. The demand for doctors will be increased, but the official use made of their services must be determined by the situation as it changes. The staffs of hospitals in areas which prove to be untenable must of necessity be transferred elsewhere, while the staffs of safer hospitals will have to be augmented, either by using part time medical men in the neighbourhood or by the appointment of whole-time resident physicians and surgeons. Mobile surgical teams and other visiting specialists are being appointed to cover particular areas.

These arrangements are being made by the hospitals themselves on the advice of the Hospital and Group Officers and with the approval of a Central Emergency Committee of the British Medical Association, which acts under the authority of the Ministry of Health and is representative of all sections of the medical profession. The headquarters of this committee is at B.M.A. House, Tavistock Square. The committee has in turn formed Local Emergency Committees representing the profession in various centres. It has prepared a register of practically all the doctors in the country, with particulars of their qualifications and experience. Rates of [illegible] eration for whole-time and part-time service have been [illegible] the Ministry after consultation with the British Medical Association and other representative bodies. They [illegible] rates paid by the fighting services, so that [illegible] ence between appointments to [illegible] hole-time appointments are [illegible] with board and lodging, which is appropriate [illegible] captain in the R.A.M.C.

aspects of professional work, appointed on the advice of the Presidents of the Royal Colleges of Physicians and Surgeons A Matron has also been appointed For purposes of administration a whole-time medical officer, known as a "Hospital Officer", has been stationed in each of the eleven Civil Commissioners' Regions into which England and Wales have been divided He in turn is assisted by the medical officers of the counties and county boroughs in his region, who act as his agents in their own respective districts In some of the larger centres of population the Hospital Officer is also assisted by a leading medical man of the district known as a Group Officer, who is primarily concerned with matters of staff, professional treatment, and the allocation of hospitals for specialized work in the grouped or affiliated hospitals of that town and the surrounding country

HOSPITAL ADMINISTRATION IN LONDON

The complex system of local government in London does not lend itself to the control of hospitals over a sufficiently wide area, and consequently London is administered somewhat differently. Greater London has been divided into ten sectors, each radiating from a centre at which is one or more of the great teaching hospitals These sectors contain many widely different types of hospital and extend well into the surrounding counties The Hospital Officer for London is assisted by a Group Officer in each of these sectors, appointed on the recommendation of what may be termed the "parent' teaching hospital of the sector The Group Officer works from a Sector Office situated at the outskirts of the sector Under the Hospital Officer he is responsible for the movement of patients within his sector, as well as for matters of staff and treatment He in turn is supported by a sector Matron to advise on the distribution of nursing staff and by a sector lay officer for non-professional work

In London, central hospitals at the apex of the sector have been reduced in size and will be used for little more than the temporary reception of casualties Patients are to be transferred at first with the utmost speed to what may be termed advanced base hospitals on the fringe of London and eventually to large base hospitals

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men appointed to senior posts, such as hospital superintendents or specialists in charge of a medical or surgical division, receive much the same pay as they would for similar posts in the Army

The function of the Central Emergency Committee is to supply the professional personnel required for the medical administration of the country as a whole, including that of the fighting services, as circumstances may prove to be necessary Its organization is designed to take into consideration personal factors, for which local knowledge is required Until called up for service in one capacity or another, medical men should remain where they are and continue with their ordinary work, if they change their address they should keep the Central Emergency Committee informed in their own interests A Central Emergency Committee for Nursing, with headquarters at Romney House, Marsham Street, London, S W 1, has also been formed The supply of hospital nurses is being greatly augmented by the Civil Nursing Reserve, which consists of trained nurses and assistant nurses not at present serving in hospitals, or as district nurses, or in public health work, and of nursing auxiliaries, who are now being recruited and trained.

STORES AND EQUIPMENT

Vast quantities of hospital stores and equipment are being manufactured, and some 100,000 casualty beds, with the necessary bedding and ward equipment, have been issued to selected hospitals All hospitals have been asked to keep a month's supply of expendable stores in hand, and they will draw their supplies direct from their own suppliers, as in times of peace Large reserves of drugs and dressings have also been accumulated in various parts of the kingdom to meet any unforeseen shortage, or for use when transport arrangements may be difficult and uncertain.

Local authorities are being encouraged to develop and expand whatever blood transfusion services exist in their district In London the Medical Research Council has arranged for the establishment of a series of depots or empanelling stations for the registration and testing of donors These donors will be asked to

attend the nearest depot as soon as their services are required. Large quantities of blood, which will keep for some three weeks will be collected and stored under suitable conditions.

FINANCE AND TRANSPORT

Rates of payment by way of advances have been worked out by the Ministry of Health and the British Hospitals Association pending a review of the cost of providing these services but it is agreed that additional temporary financial assistance may well have to be provided. A war of long duration and the subsequent drying up of voluntary subscriptions may well cause serious financial embarrassment to institutions depending on charity a position of which the Government is fully aware It is not, however possible in an article of this kind to discuss the many financial difficulties which will affect all hospitals in time of war

No hospital scheme would be complete without adequate transport. In every district there will be fleets of ambulances consisting of single-deck passenger buses specially fitted for the carriage of stretchers. Most of them will be able to take from eight to ten lying cases. They will operate between the hospitals or between hospitals and trains, and are not intended for the collection of casualties in the street, for which smaller commercial vehicles are being used, usually adapted to take two or four stretchers.

PREPARATORY MEASURES

Every hospital included in the Ministry s arrangements knows at the outbreak of war of the part it is expected to play As many patients as possible will be sent home, and about 100 000 beds will be freed in twenty four hours Additional beds will be put up in the wards, most of them being supplied by the Government and beds will be installed in spare accommodation not now used as wards—to provide another 100 000 beds In certain towns where by these means alone enough beds might not be made available for the immediate reception of casualties, a selected number of patients will be moved by ambulance or train to other institutions in safer areas pending their recovery and discharge. In the course

of time certain hospitals may be freed entirely for acute work by the transfer and concentration of chronic sick elsewhere Such arrangements are far from ideal, and will seriously inconvenience the smooth running of the institutions concerned But beds have to be found No one can foretell the extent of the casualties from enemy raids or service overseas or the extent to which beds for ordinary sick may be required for the civil population, many of whom will be living away from home Although huts are being added to more than 100 hospitals and institutions in order to provide some 40,000 new beds, and one or two entirely new hospitals are to be built in districts where there is a pressing need, these new beds alone might be unable to cater for the increased demand. Every institution must then be prepared to strain its existing accommodation to the utmost at least in the first few months of war. There is reason to believe, however, that most hospitals fully realize their responsibilities and are fully prepared to suffer whatever sacrifices may be necessary to ensure a final victory.

[1] ORGANIZATION OF THE EMERGENCY MEDICAL SERVICES

II FIRST AID POSTS

By C SEELEY M B, B S D P.H.

Under the Air Raid Precautions Act 1937, and the Air Raid Precautions (General Schemes) Regulations, 1938 county councils and county borough councils (and a few smaller authorities) are charged with the responsibility of setting up certain medical services. These services include arrangements for the collection of casualties by means of what are called first aid parties or stretcher parties, their transport to aid posts or receiving hospitals and their treatment in the aid posts or in country areas at first aid points. Local authorities are not now responsible for hospital treatment or for inter hospital transport which are the direct responsibility of the Ministry of Health and the Department of Health for Scotland but all branches of the casualty service are closely related and apart from the recruiting of personnel and their preliminary training and arrangements for first-aid parties are now all controlled by the Health Departments.

The difficulty of planning a suitable first aid service lies in the absence of any data or experience on which to estimate the number of the casualties likely to be caused or the places where they may be expected to occur Conditions in Spain China or Abyssinia where there was practically no ground defence and very inferior air defence were very different from the conditions which now prevail in England In addition the possible use of gas complicates the arrangements to be made It is significant that gas was not used in Spain or China, and not, it may be supposed, from motives of humanity It was used in Abyssinia

[1] This article was written before the outbreak of war

against troops without cover, without personal protection, and without any training in defence measures But while it would be unsafe to conclude that it would not be used in England, even if only in an attempt to cause panic and to hamper defence measures against other forms of bombing, some protection against mustard gas is comparatively easy and the casualties caused should not be very severe Gas is a bulky substance to carry in an aeroplane, and its military value against civilians in houses is insignificant compared with high-explosive or incendiary bombs Nevertheless casualties may be caused by mustard gas, and arrangements for their treatment must be made

One of the main anxieties of the larger general hospitals is that their proper work of dealing with severely injured cases requiring in-patient treatment might be seriously hampered by the arrival of large numbers of less seriously injured persons demanding attention In order, then, that these hospitals may function to the best advantage an efficiently organized system of first-aid parties and first-aid posts is essential

FIRST-AID PARTIES

Each first-aid party consists of four men, fully trained in first aid They are stationed at depots throughout the district, and on receiving information that casualties have occurred at a particular place, will proceed with their stretcher, either on foot or in a car provided for the purpose, to the site, to which one or more of the small street ambulances will also be sent. Each member of the first-aid party carries a pouch with first-aid requisites, and is trained to give such attention as is necessary to save life or to allow the casualties to be moved Members of the party must exercise discrimination in the initial disposal of cases, either sending them home or to a first-aid post or a hospital, as may be appropriate It is important that, during the periods of activity and pressure immediately following a raid, hospitals and aid posts should not have unnecessary work thrown upon them, as would be the case if casualties which ought to have gone to aid posts arrived at hospitals and others whose injuries necessitated immediate hospital treatment were sent to aid posts.

Serious cases should be transferred to hospitals direct if they are likely to require in patient treatment

It would be ideal for a doctor to go to the site of a raid and be the first to see the patient but enough doctors will not be available after the calls of the fighting services, the civil hospitals, the aid posts, and districts receiving evacuees have been met.

AMBULANCE TRANSPORT

Every scheme-making local authority has earmarked a number of commercial vehicles to serve as ambulances. Fittings have been made which convert the vehicle into an ambulance capable of carrying two or four stretcher cases for at least a short distance in comparative comfort These street ambulances are stationed at depots throughout the district They will take cases direct from the scene of the accident to hospital or to an aid post, as advised by the leader of the stretcher party Each ambulance has an orderly in attendance in addition to the driver

FIRST AID POSTS

The functions of aid posts may be stated to be (*a*) To act as a buffer to the hospitals and so prevent them from being over crowded by the less seriously injured (*b*) To give immediate and initial treatment to such seriously injured casualties as may for one reason or another come to the aid post before going to hospital. (*c*) To treat and send to their homes the slightly injured including persons suffering from nervous shock. (*d*) To provide cleansing facilities for persons who have been contaminated by gas, either wounded or unwounded unless separate cleansing stations have been set up for the unwounded.

In order to fulfil these conditions, and to utilize buildings which can be adapted at short notice and which the public are already accustomed to associate with medical treatment, aid posts have been sited at hospitals or clinics wherever possible or in buildings close to hospitals. It is a guiding principle in military surgery that casualties must be evacuated from the front line as soon as possible. Conditions on the home front will be different, inasmuch as there will be no front line with com

munications leading back to the rear by way of the casualty clearing stations Nevertheless, it will still be desirable to move casualties out of the danger area as soon as possible Hence major surgical work should not be undertaken at aid posts From the very position of the aid post, however, as the first medical unit in the casualty organization, patients may well be admitted who require immediate surgical intervention before they can safely be moved to the casualty receiving hospital In order to give such treatment, to superintend the work of the staff, to administer dangerous drugs or tetanus antitoxin, and above all to make an accurate diagnosis of the extent of the injury and of the type of treatment required, medical men are placed in charge of first-aid posts, and the necessary equipment provided

MOBILE UNITS

As well as fixed aid posts established in buildings, mobile aid posts or mobile units have been formed in many districts to serve the needs of a wide area A mobile unit consists of a van fitted with removable cupboards and containers in which is stored all the necessary equipment of a post The units are usually placed at hospitals or at some convenient centre at which the nucleus of a staff can be quickly collected Such mobile units will go to the scene of the accident, which may be in a small township some miles away, and attend to the casualties either in the open or in some convenient building Patients will not be dressed in the vehicle itself, which is in no way intended to serve as an operating theatre, but merely as a conveyance for stores and personnel

First-Aid Points

An aid point is little more than a box of dressings placed in the surgery of a doctor or in the house of a district nurse or at some point where the few casualties which may be expected can be collected and given first-aid treatment pending the arrival of a mobile unit or an ambulance.

ADMINISTRATION AND LAY-OUT

First-aid posts should have facilities both for first-aid work and for the cleansing of persons contaminated by gas Aid posts

vary in their individual lay-out according to the accommodation available but in general they consist of a receiving room, a treatment room and a rest room in which patients can wait before going home or being removed to hospital. Patients will not be kept in an aid post for longer than is necessary Arrangements for cleansing gas-contaminated persons are also made in separate rooms if they are available

First Aid Section

This consists of (1) A reception room to which casualties are admitted the extent of the injury assessed, personal belongings and valuables collected in a bag and a casualty record card M.P C 44 made out (2) A first aid room where the necessary medical treatment is given and notes made on the casualty record card particularly the administration of morphine or any other information of value in subseqnent treatment (3) An evacuation or rest room in which patients can wait pending discharge home or to hospital a separate casualty card M.P C 46 will be used for patients being transferred to hospital, and will be sent along with the patient.

Cleansing Section

Outside the reception room there should be an open shed where grossly contaminated outer clothing can be removed and put into bins before the patient enters the building where any further clothes may be removed. A separate cleansing room where washing facilities are provided and prophylactic or bleach treatment carried ont may or may not be provided but where a separate room is not available or cannot be easily provided washing facilities should be available in the reception room. A dressing room where cleansed persons are provided with clothing may or may not be the same room as that used for the discharge of non-contaminated casualties Separate accommodation for the sexes is not essential. Where the building does not lend itself to separation screens or curtains can be made to provide the necessary privacy

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Outside the reception room there should be an open shed where grossly contaminated outer clothing can be removed and put into bins before the patient enters the building where any further clothes may be removed. A separate cleansing room where washing facilities are provided and prophylactic or bleach treatment carried out may or may not be provided but where a separate room is not available or cannot be easily provided washing facilities should be available in the reception room. A dressing room where cleansed persons are provided with clothing may or may not be the same room as that used for the discharge of non-contaminated casualties. Separate accommodation for the sexes is not essential. Where the building does not lend itself to separation screens or curtains can be made to provide the necessary privacy.

PERSONNEL

First-aid posts come under the general administrative control of the medical officer of health, and are under the immediate executive control of a medical officer placed in charge of the post. In many cases local authorities have designated the doctors for this work in consultation with the Local Emergency Committee. The medical officers appointed are paid in peace time a fee of twenty guineas a year, and are responsible for the collective training of the personnel In this way they get to know the personnel of their posts, and a team spirit is introduced which adds to its efficiency. A large post, excluding reserves, consists of a doctor and a staff of sixty (ten men and fifty women), a small post of a doctor and forty (seven men and thirty-three women), each divided into three eight-hour shifts A mobile unit consists of a doctor and seven men or women per shift The team should if possible include at least one trained nurse and a number of nursing auxiliaries Where required for the large posts a small skeleton staff of ten per shift may be employed whole-time, but the others will be part-time volunteers It is highly probable that most aid posts will never treat a single casualty, and it may well happen that in the course of a war lasting perhaps for some years many of them may be given up

When the air raid warning signal is given the shift liable for duty should report at once, if they can reach the post before the raid begins, if not, they must try to get there as soon as the streets are reasonably safe One of the advantages of having a post sited at or near a hospital is that some staff is always available, ready to start work as soon as the first casualties begin to arrive First-aid parties or stretcher bearers do not form part of a first-aid post They are more closely associated with other A R P workers, such as rescue and demolition parties, and consequently are stationed at or near the depots to which the earliest information of the raid will come The medical officer of an aid post is not responsible for the training or organization of first-aid parties.

Aid posts vary so much in size, in lay-out, in the number of

casualties they may be expected to treat at one time, and t conditions under which they may have to work that no unifo standard of organization is possible or desirable. What ma be suitable in a large aid post in a congested city liable to be t object of repeated and concentrated attack would be qu inappropriate for an aid post in a small and remote country tov The work will be very similar to that of a busy surgical o patient department, with the addition of a separate staff dealing with persons contaminated by gas if any such ca should occur Selected attendants will be required to be on du at the door to prevent the entrance of unauthorized persons well as to help with the reception of casualties. Clerks, messe gers and store-keepers will also be required. The medical offi in charge is required to conduct at least twelve training sessic in the year and will probably find that the judicious choice o suitable man or woman to serve as adjutant and be responsi for the allocation of duties and the general supervision of t organization will relieve him of much non-clerical work. Nev theless this will not relieve him of his primary responsibility the efficient administration of the post. A quartermaster store-keeper is an equally important member of the team. M than half the staff will be employed in non medical duties, b it is desirable that all should be as highly trained in first aid is possible. Training parades should include practical work first aid and anti-gas measures, a limited number of lectures the medical officer and practice in dealing with a rush of casu ties, preferably in combination with the practices of first-a parties and ambulances. Each member should be given opportunity of obtaining practice and experience in the vario duties of the post.

CONCLUSION

It is an axiom that every great war is different from the la No well-defended country with efficient ground defences and active and adequate air force has as yet been the subject of aer bombardment and though the speed of modern aircraft mal it probable that a number of machines may penetrate the defenc

it is impossible to foretell what life in large cities will be like Certainly conditions will be in no way comparable to that of troops in the last war exposed to long-continued periods of intense bombardment in comparatively shallow trenches, from which they might not move. In most towns in England attacks will be sudden and almost unexpected, and will be followed by long periods of complete safety. The casualty service must therefore be one which can be relied on to function in all parts of the country at short notice after long periods of comparative peace Later on it will probably be necessary to modify the arrangements in the light of experience, but for the first few weeks the policy must be one of hoping for the best and preparing for the worst.

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